EXHIBIT 14

Jacklyn Kelley, Individually and Joshua Kelley, Individually and as Personal Representative of the Estate of A.K. v. Fisher Price Inc., Mattel, Inc. and Amy Renee Williams a/k/a Amy Morin, US Southern District of Texas

Biomechanical Engineering Report

Erin M. Mannen, Ph.D.

Prepared for:
Arnold and Itkin
July 11, 2022

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1. Summary

I was contacted by Arnold and Itkin regarding circumstances surrounding the death of [redacted] Kelley. I was asked to determine if and how the design of her sleep product influenced the biomechanics (movement and body position) of [redacted] Kelley in the context of suffocation risk. I am uniquely qualified to serve as a biomechanics expert in this case. In my 2018 to 2019 study funded by the United States Consumer Product Safety Commission, I led a team of engineers and clinicians to conduct in-depth investigation reviews, product characterizations, and a peer-reviewed *in vivo* biomechanics research study on 15 living human babies to understand how their body position and movement was impacted by inclined sleep products. One result of the study concluded that the inclined sleep products put babies in a flexed-trunk position during supine lying, a position that inhibits normal breathing. The American Academy of Pediatrics recently updated its infant safe sleep guidelines, and interpreted the results of my research in the same way, concluding that sleeping in an inclined sleeper is unsafe (Moon et al., 2022).

As a part of this case, I thoroughly examined an exemplar Fisher Price Rock ‘n Play Sleeper (the product involved in Avery’s death was destroyed by the police department) using the same techniques I used in my CPSC study. I confirm that based on my examination of the product, that the Fisher Price Rock ‘n Play Sleeper product is functionally equivalent to inclined sleep products that were tested in my previous human subjects biomechanics study, meaning the results of that robust and peer-reviewed research apply to this specific case. The methodology for that study is described in detail in my peer-reviewed publications, and I incorporate that methodology by reference in this document. The methodology and results of my *in vivo* biomechanics study were therefore used in forming my opinions described in this report.

I also took additional measurements and characterized the dangerous concave design of the Fisher Price Rock ‘n Play Sleeper. The widthwise concave design results in a dangerous breathing scenario when a baby turns her head to the side.

Based on the results from my peer-reviewed *in vivo* human subjects biomechanics study, the product evaluation and measurements I took on an exemplar Fisher Price Rock ‘n Play Sleeper, and the information I learned from the case documents**, it is my opinion that the design of the Fisher Price Rock ‘n Play Sleeper resulted in a dangerous biomechanical position that contributed to the suffocation death of [redacted] Kelley.**

2. Qualifications

My name is Dr. Erin M. Mannen. I earned a Ph.D. in Mechanical Engineering from the University of Kansas, completed a Postdoctoral Fellowship in the Center for Orthopaedic Biomechanics within the Department of Mechanical and Materials Engineering at the University of Denver, and have been researching biomechanics for over 12 years. I am currently employed full-time as an assistant professor in the Mechanical and Biomedical Engineering Department at Boise State University in Boise, Idaho. I teach engineering courses and conduct infant biomechanics research as Director of the Boise Applied Biomechanics of Infants (BABI) Lab. My current research focuses on how babies move and use their muscles, and what that means for musculoskeletal development and safety in commercial infant gear. My research has been funded by the United States Consumer Product Safety Commission ("CPSC"), the National Institutes of Health through COBRE funding, the International Hip Dysplasia Institute, and through partnerships with industry. My collaborative research adapts commonly used biomechanical experimental equipment and study designs to understand the unique and understudied infant population. I collaborate with orthopaedic clinicians, pediatric pulmonologists, pediatric developmental experts, and fellow engineers and biomechanists across the United States. I have over 45 peer-reviewed publications related to biomechanics and am an active member of the Orthopaedic Research Society and the American Society of Biomechanics, where I was recently honored by my peers with the 2021 Early Career Achievement Award for my research in infant biomechanics which includes my peer-reviewed infant inclined sleep product study presented as part of this report. A full list of my scientific journal publications is provided as *Appendix A: Peer-Reviewed Publications in Scientific Journals over the Past 10 Years*. I submit this expert report independently as a consultant, and not in conjunction with my role at my full-time employer. My curriculum vitae is attached as Exhibit A.

3. Background Information and Facts Considered

3.1 Incident Details

The following documents were provided to me in preparation for my work on this case:

1. Complaint filed by Plaintiff
2. Deposition of Jaclyn Kelley and associated exhibits
3. Deposition of Joshua Kelley
4. Deposition of Amy Williams Morin and associated exhibits
5. Deposition of Barbara Glanowski and associated exhibits
6. Deposition of Bryan Brown and associated exhibits
7. Deposition of Catherine Pilarz and associated exhibits
8. Deposition of Daniel Smith and associated exhibits
9. Deposition of Donald Fest and associated exhibits
10. Depositions of Dr. Gary Deegear and associated exhibits
11. Deposition of Emily Skow and associated exhibits
12. Deposition of Jerry Miller and associated exhibits
13. Deposition of Joel Taft and associated exhibits
14. Deposition of Justin Taton and associated exhibits
15. Deposition of Linda Chapman and associated exhibits
16. Deposition of Margo Moulin and associated exhibits
17. Deposition of Michael Steinwachs and associated exhibits
18. Deposition of Sarah Ford and associated exhibits
19. Exponent Presentation 2018-04-06
20. Exponent Presentation 2018-06-08
21. House Committee on Oversight and Reform, Sleeping Danger: The Rock ‘n Play and Failures in Infant Product Safety hearing. June 7, 2021.
22. “Infant Deaths in Inclined Sleepers: Fisher-Price’s Rock ‘n Play Reveals Dangerous Flaws in U.S. Product Safety,” Prepared for Chairwoman Carolyn B. Maloney, Staff Report, Committee on Oversight and Reform, U.S. House of Representatives, June 2021.
23. MATTEL-KE-0000001 to MATTEL-KE-1163775

[redacted] Kelley (Female, DOB 07/18/2015, 38 weeks gestation, white) was placed in a Fisher Price Rock ‘n Play Sleeper by her day care provider, Amy Williams Morin, at the age of 4.9 months

in Corpus Christi, Texas. A couple of hours later, she was found with her face pressed into the side of the sleeper, not breathing and unresponsive. [redacted] was pronounced dead shortly thereafter. The autopsy report indicated a normally developed baby with a head circumference of 41 cm (diameter of 13.1 cm). The cause of death was listed as sudden infant death syndrome, and the manner of death was listed as undetermined.

The Rock 'n Play Inclined Sleep product was first introduced to the market by Fisher Price in 2009. The new product featured an inclined back with a seat-like design, and the product was marketed for overnight sleep. The U.S. Congressional report notes that Fisher Price did not conduct a hazard analysis related to the safety of the incline angle, nor were any pediatricians nor biomechanical engineers involved in the design of the product. Well-accepted methods common in the biomechanics community were not used to evaluate a baby's body position within the inclined sleep product during the design process nor after the product was being sold.

Fisher Price received notifications of safety concerns from numerous regulators and experts worldwide and were made aware of injuries and deaths associated with the product as early as 2012. Fisher Price has testified that it sold approximately 4.7 million Rock 'n Play Sleepers before the product was recalled in 2019.

3.2 My Previous 2018-2019 U.S. CPSC Inclined Sleep Product Study

My expertise is uniquely suited for inclined sleep product-related cases. From 2018 to 2019 when I was a faculty member in the Department of Orthopaedic Surgery at the University of Arkansas for Medical Sciences, the CPSC contracted with my institution for me to lead a team of clinicians and engineers to study inclined sleep products. There were three main parts of the study: (1) summarizing of incident reports, (2) product analysis, and (3) *in vivo* human subjects biomechanics experiment (U.S. CPSC, 2019). Each portion of the study is briefly summarized below.

Incident Reports

My team and I first reviewed documents from 91 incidents (deaths, injuries, and hazards) occurring in inclined sleep products. The main conclusion from this portion of the study was that two main scenarios were common: a baby was placed supine and found supine (supine-supine), and a baby was placed supine and found prone (supine-prone). The supine-supine scenario was common with younger babies (average 3.2 months), while babies who experienced a supine-prone event were slightly older (average 4.2 months). The detailed methodology and discussion from this portion of the study is provided as *Appendix B: In-Depth Investigation Analysis from U.S. CPSC Study.*

Product Analysis

My team and I measured and characterized 14 products in the inclined sleep product class. Some of my work with the United States Consumer Product Safety Commission remains confidential, so I am unable to disclose specific manufacturers or products which were included in the study. However, the report concluded that a range of product designs and incline angles were present in the product class, and detailed measurements were included as part of the study (*Appendix C: Product Characterization Methods from U.S. CPSC Study*).

Human Subjects Biomechanics Experiments

My team designed this portion of the study to understand how (1) an incline angle alone, and (2) the specific products within the inclined sleeper class impact a baby's ability to move and use their muscles during supine and prone lying. The goal of the study was to understand how and if the design of inclined sleep products impacted suffocation risk from a movement and body position perspective. I used experimental biomechanics equipment and techniques to measure body position via motion capture (Figure 1A) and electromyography sensors to measure muscle activity (Figure 1B) to gain a holistic understanding of how babies are positioned and moving within each condition. By first isolating the incline angle and studying babies lying on inclined crib mattresses, we were able to remove other variables of specific inclined sleeper designs (Figure 1C and 1D). Then, the second part of the study allowed us to understand how inclined sleepers with various designs impacted movement and muscle activity of babies (Figure 1E and 1F). As part of the original CPSC study, 10 babies were tested. However, my team increased the sample size to 15 babies and have subsequently published those results in two different manuscripts in the peer-reviewed Journal of Biomechanics (Wang et. al, 2020; Wang et. al, 2021). Of note, a selected few inclined sleep products were included in the peer-reviewed publication (Figure 2).

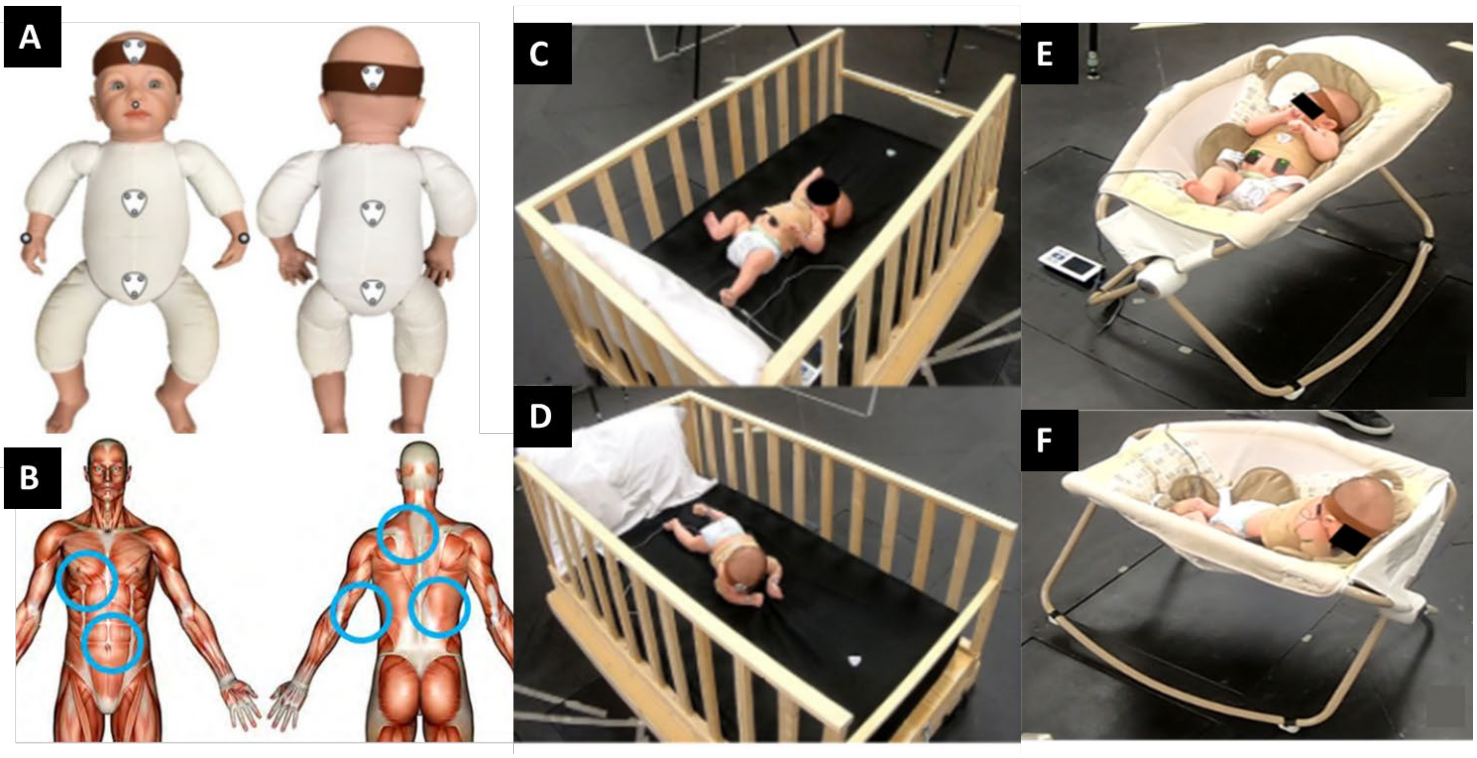

Figure 1. Experimental setup including: (A) reflective marker locations, (B) electromyography sensor locations, (C) supine lying on a flat crib mattress, (D) prone lying on a flat crib mattress, (E) supine lying in an inclined sleep product, and (F) prone lying in an inclined sleep product (CPSC, 2019; Wang et. al, 2020; Wang et al., 2021).

Figure 2. Figure taken from Wang et al., 2021, showing the products included in the peer reviewed study. The measurements from *product a* (top left) are consistent with measurements taken from products S01, S02, S09, and S10.

I highlight two main findings from my 2021 human subjects study that are specific for a **supine-to-supine** scenario:

(1) "Our results show no changes in neck and trunk ROMs in the inclined products compared to the flat surface during supine positioning. Infants also showed no differences in the number of times they lifted their heads in the inclined products, but they had significantly fewer trunk movements in the inclined products during supine lying. We have previously demonstrated that increased incline angle of a flat crib mattress surface resulted in more neck motion and no changes in trunk motion (Wang et al., 2020). The difference in findings is likely due to a lack of surface firmness, increased curvature of the inclined sleep products, and the design feature of a seat compared to the inclined crib mattress from our

previous study. Decreased trunk movement, even while infants were unsecured, was found in all types of inclined sleep products (various angles, plastic/ no plastic surfaces, various padding). When babies are positioned supine in inclined sleep products, positional conformity occurs, forcing the infant trunk into a more flexed position, up to 16.3° in the products examined in this study (likely due to the absence of firm support or due to heavy padding, or a combination of the two). Thus, the design of the inclined sleep products is promoting a more flexed spine, and preventing further trunk flexion during supine lying, in agreement with our results. Additionally, no changes in the neck and trunk muscle activity were found in the inclined products compared to the flat mattress surface. Because the babies are already in a flexed trunk position, further voluntary trunk flexion may be more difficult to achieve or may be impossible, leading to less sagittal plane trunk movement. However, we did not see this same phenomenon in the neck motion results, suggesting that although the trunk is unable to flex, the head is still able to experience ROMs similar to the flat crib mattress." (Wang et al., 2021).

In the specific case of [redacted] *Kelley, here is what these findings mean:*

(a) The inclined sleeper represents a different mechanical environment than an angled firm and flat crib mattress, evidenced by the differing results in our biomechanics studies when comparing infant movement and muscle activity on an inclined mattress and within inclined sleepers. The inclined sleeper is not equivalent to a firm and flat crib mattress at an incline.

(b) The inclined sleeper promotes a flexed-trunk body position, rendering additional trunk movement difficult. This means that if [redacted] wished to move within the product, her neck was the only available spinal segment to maneuver. The position the inclined sleeper puts a baby's body in makes it easier for babies to obtain the dangerous chin-to-chest position.

(2) "We previously observed that infants were not able to maintain a stable supine-lying posture at 30° inclined crib mattress surfaces due to sliding down the incline (Wang et al., 2020). So, inclined sleep products require a seat design feature to prevent infants from sliding at higher inclines. The combination of a steep incline and the seat feature subjects babies into a position that might more accurately be considered a reclined sitting posture rather than a lying posture. Other researchers have reported that changes in trunk posture impact pulmonary and respiratory function. For instance, Lin et al. found that a flexed trunk

posture during sitting, not unlike the reclined flexed trunk sitting posture of the infants in our study, resulted in reduced lung capacity and lower expiratory flow compared to a normal standing posture (Lin et al., 2006). Another study demonstrated that slumped sitting posture altered ribcage configuration and chest wall movements compared normal sitting posture during breathing (Lee et al., 2010)." (Wang et al., 2021).

In the specific case of [redacted] *Kelley, here is what these findings mean:*

(a) The inclined sleeper cannot be accurately described as a lying surface, evidenced by the inability of babies to maintain their position without sliding down inclines of 30° or more, and the design of the seat portion which forces the infant's hips into a flexed position.

(b) The inclined sleeper promotes a flexed-trunk position. Infant breathing is not as robust as adult respiration; therefore, body position in babies is even more concerning compared to adults with fully developed respiratory systems. In this sense, a flexed-trunk posture similar to the posture of the infants in the inclined sleep products in my study puts infants at higher demand to maintain pulmonary function, leading to an increased risk for suffocation.

The results of my CPSC study showed that an inclined sleeping surface and the design of an inclined sleep product significantly impacted a baby's body position and ability to move compared to a flat crib mattress. My team concluded that the unique design features of the incline angle, seat design, lack of firmness, and product conformity were the main contributors to the body position and movement differences we saw in the babies between the inclined sleep products and a flat crib mattress.

Confidentiality Statement

I am contractually obligated to maintain confidentiality regarding the incidents, products, and manufacturers which were included in my CPSC study. Therefore, I am unable to confirm or deny that any specific product or manufacturer was a part of the study. In this case of [redacted] Kelley which involves the Fisher Price Rock 'n Play Sleeper, I cannot confirm or deny that this product was included in my study with the CPSC.

4. Methodology and Procedures

The methods used in my analysis of the Fisher Price Rock ‘n Play Sleeper are the same methods I used in my previous inclined sleeper project with the U.S. CPSC (CPSC, 2019). Specifically, the product measurements I used are detailed in ASTM F3118-17a: Standard Consumer Safety Specification for Infant Inclined Sleep Products. This specific use in measuring inclined sleep products was subsequently published in the peer-reviewed *Journal of Biomechanics* as part of Wang et. al, 2021. In addition to the published methods, I also performed additional concavity measurements which were of specific interest to this case.

The methods used in the biomechanical study conducted as part of my previous inclined sleeper product with the U.S. CPSC (CPSC, 2019) are common experimental techniques (motion capture, electromyography, and oxygen saturation) that have used in peer-reviewed research on infants since the 1980s (Praud et al., 1991; Savelsbergh GJ and van der Kamp J., 1994; Thelen, 1986; Lopes et al., 1981). The techniques are accepted within the community as the gold standard methods of experimental data collection. The specific methods I used have been published in the peer-reviewed Journal of Biomechanics (Wang et. al, 2020; Wang et. al, 2021). The methods I used to study these infants are not novel but are instead considered the gold standard to study human movement in a biomechanics laboratory and were the gold standard at the time the Rock ‘n Play was being developed.

5. Application of Facts to the Methodology

5.1 Product Characterization

Separate from my work with the CPSC, I independently evaluated a Fisher Price Rock ‘n Play Sleeper product using the same techniques used in the *Product Analysis* conducted as part of the CPSC study (see *Appendix C* for detailed methodology), and I compared the measurements to the results from the 14 products in the CPSC study.

On June 25, 2022, I examined and measured my personally-owned Fisher Price Rock ‘n Play Sleeper (model DMJ22) in my home since the product [redacted] died in had been destroyed. Based on the photos in the police report, the Fisher Price Rock ‘n Play that [redacted] died in appeared to be correctly assembled and in good working order, and similar to my Fisher Price Rock ‘n Play Sleeper (Figure 3). I noted that the 3-point harness straps were not visible through the slits in the soft goods. No mechanical alterations were observed in the photos.

Figure 3. Photos from the police report showing the Fisher Price Rock ‘n Play product that [redacted] died in.

I examined the exemplar product alone. I first confirmed the hard floor was flat (±0.2°) using an inclinometer, then I took photos and made general observations about the product. Based on my experience with inclined sleep products, the product was assembled correctly according to manufacturer instructions and in good working order from a mechanics standpoint. Figures 4A and 4B show the product, and Figures 4C and 4D show example photos of angle measurements on the product.

Figure 4. (A) Photo of Fisher Price Rock 'n Play Sleeper; (B) Overhead view of product; (C) Product with the hinged weight gage placed as instructed in ASTM voluntary standard and showing an incline angle of 26.9°, and (D) a thigh angle of 44.95

I then conducted a thorough product analysis using techniques detailed in the CPSC Study (Appendix C). The results of the measurements are presented below as Table 1. Care was taken to place the hinged weight gage into the product in a repeatable fashion according to the methodology outlined in Appendix C. I also measured the "Depth at Hinge" of this product as an additional measure.

Table 1. Measurements of the Fisher Price Rock 'n Play Sleeper product. Each measurement was taken three times, and the average of the three measurements was calculated.

	Minimum Incline at Head	Maximum Incline at Head	Thigh Angle at Minimum Incline	Thigh Angle at Maximum Incline	Side Height at Head	Usable Length	Width at Shoulder	Width at Hinge	Width at Knee	Maximum Width	Minimum Width	Minimum Incline with Rock	Maximum Incline with Rock	Curved Plastic Molding	Thin Plasic Molding	Side Mesh	Depth at Hinge
Trial 1	27.5	N/A	42.7	N/A	15.3	43.4	44.8	43.4	37.6	44.9	32.1	25.4	34.0	Y	N	Y	27.0
Trial 2	28.1	N/A	43.5	N/A	15.1	43.6	45.1	43.2	37.6	45.2	32.0	25.9	34.7	Y	N	Y	27.1
Trial 3	26.9	N/A	44.5	N/A	15.1	43.7	44.7	43.4	37.1	44.9	32.1	25.1	34.9	Y	N	Y	26.8
Mean	**27.5**	**N/A**	**43.6**	**N/A**	**15.2**	**43.6**	**44.9**	**43.3**	**37.4**	**45.0**	**32.1**	**25.5**	**34.5**	**Y**	**N**	**Y**	**27.0**

These measurement results were compared with the product measurements from the 14 products studied as part of my CPSC study (Table 2). Every value within either 2 cm or 2°, or a match from a Yes/No category is highlighted in yellow in Table 2. Three products (S01, S09, and S10) exhibited >75% matches, with product S01 matching all measurements.

Table 2. Modified CPSC study table of measurements with yellow indicating close measurements with the Fisher Price Rock 'n Play Sleeper (±2 cm, ±2°, or a Y/N match), and a red box indicating the product with matches in at least 75% (12/16 categories). Product S01 matched in 16/16 categories.

Sample	Minimum Incline @ Head (deg)	Maximum Incline @ Head (deg)	Thigh Angle @ Minimum Incline (deg)	Thigh Angle @ Maximum Incline (deg)	Side height (Depth at 11.4") (cm)	Usable length (Hinge, to top of backing seam/ head location) (cm)	Width at Shoulder (at 11.4") (cm)	Width at Hinge (cm)	Width at Knee (cm)	Maximum Width (cm)	Minimum Width (cm)	Minimum Incline (w/Rock) (deg)	Maximum Incline (w/Rock) (deg)	Curved / Thick Plastic Molding? (Y/N)	Thin Plastic molding? (Y/N)	Side Mesh? (Y/N)
S01	27.7	x	44.5	x	13.3	43.2	46.7	43.5	37.1	46.7	32.1	26.2	36.5	Y	N	Y
S02	24.4	x	51.7	x	14.0	45.1	47.3	16.8	38.7	51.8	32.4	23.0	31.7	Y	N	Y
S03	25.5	x	24.3	x	17.1	43.5	39.7	39.7	38.7	41.0	34.0	x	x	N	N	Y
S04	26.0	x	23.9	x	15.6	41.6	40.0	40.6	39.1	40.6	34.3	x	x	N	N	Y
S05-high	12.2	38.7	4.4	1.1	6.7	42.2	34.3	36.8	32.4	36.5	27.9	34.0	41.9	Y	N	Y
S05-low	x	x	x	x	20.0	39.4	30.2	35.6	32.4	x	x	10.7	18.3	x	x	x
S06	31.1	x	22.0	x	11.7	39.4	41.6	43.2	40.6	43.8	30.2	29.1	35.6	N	N	Y
S07	9.3	x	24.5	x	25.1	42.5	51.8	48.6	41.0	51.8	30.2	4.2	15.0	Y	N	Y
S08	31.3	x	38.2	x	3.8	43.5	42.9	40.6	35.2	41.9	18.4	29.8	36.4	N	N	N
S09	20.9	x	52.1	x	14.6	43.5	45.1	43.2	37.8	45.4	31.4	18.8	26.8	Y	N	Y
S10	25.7	x	52.6	x	13.7	44.5	44.5	43.2	38.1	44.5	31.1	24.7	30.0	Y	N	Y
S11-high	11.8	20.5	31.4	22.9	22.2	39.4	50.5	47.3	42.2	51.4	35.6	14.3	17.1	N	Y	Y
S11-low	x	x	x	x	21.9	40.0	49.8	48.9	42.2	x	x	20.3	22.4	x	x	x
S12-high	11.7	25.7	29.0	21.7	23.2	43.5	47.0	46.4	45.1	48.3	22.9	x	x	Y	N	Y
S12-low	x	x	x	x	26.0	43.5	47.3	46.0	43.5	x	x	x	x	x	x	x
S13	21.5	x	25.9	x	14.8	40.0	47.3	43.2	40.6	48.9	41.3	16.8	29.0	Y	N	Y
S14	16.9	x	44.2	x	11.4	44.1	48.3	48.6	43.2	48.9	38.1	10.8	20.6	Y	N	N

Products S01, S09, and S10 are functionally equivalent to the Fisher Price Rock 'n Play Sleeper, the Fisher Price Rock 'n Play Sleeper, which is the same product that [redacted] Kelley died in. My previous CPSC report states that products S01, S02, S09, and S10 are all from the same manufacturer (see Appendix C). Products S01 and S09 are described as basic versions of the inclined sleeper product, while Products S02 and S10 are described as deluxe versions of the inclined sleeper product. Additionally, the "Depth at Hinge" measurement of 27.0 cm was close to the measurement of 25.4 cm taken of Product S02 as part of my CPSC study.

Similarly, I took additional measurements described in Appendix C to characterize the design of the soft goods in order to compare the Fisher Price Rock 'n Play Sleeper to those included in my CPSC study. Table 3 shows the results.

Table 3. Distances of materials from sleeper construction measured from midline (all in cm). "At 11.4"' represents the head region; "At Hinge" represents the pelvic area; "At Knee" represents the end of the hinged weight gage.

	At 11.4"				At Hinge				At Knee			
	Plastic	*Solid*	*Mesh*	*End*	*Plastic*	*Solid*	*Mesh*	*End*	*Plastic*	*Solid*	*Mesh*	*End*
Trial 1	16.1	18.7	21.6	28.3	11.2	14.0	28.9	38.7	n/a	13.5	19.9	26.0
Trial 2	15.9	18.2	21.5	28.0	13.0	16.1	32.5	37.6	n/a	14.0	22.1	28.1
Trial 3	16.2	18.7	21.8	28.9	11.4	14.4	29.2	37.3	n/a	14.2	20.1	28.0
Mean	**16.1**	**18.5**	**21.6**	**28.4**	**11.9**	**14.8**	**30.2**	**37.9**	**n/a**	**13.9**	**20.7**	**27.4**

I then compared these measurements to measurements taken from the 14 products included in the CPSC study. Every value within 2 cm or an "x" match indicating "not applicable" is highlighted in yellow below, and products with >80% matches (10 of 12) in the measurements are boxed in red (Table 4).

Table 4. Modified CPSC study table of measurements with yellow indicating close measurements with the Fisher Price Rock 'n Play Sleeper product (±2 cm, or an "x" match), and red boxes indicating products with >80% (10 of 12) of the measurements matching.

Sample	at 11.4"				at hinge				at knee			
	Plastic (cm)	Solid (cm)	Mesh (cm)	End (cm)	Plastic (cm)	Solid (cm)	Mesh (cm)	End (cm)	Plastic (cm)	Solid (cm)	Mesh (cm)	End (cm)
S01	15.2	16.5	22.2	29.2	12.7	14.0	30.8	39.1	x	13.0	21.3	27.9
S02	15.9	19.4	22.2	29.2	12.1	14.9	31.8	38.7	x	14.0	21.6	27.3
S03	x	12.1	24.1	29.2	x	11.1	x	39.4	x	12.7	x	34.9
S04	x	13.0	24.1	29.5	x	11.4	34.0	40.6	x	10.8	28.9	34.9
S05-high	15.2	17.1	20.3	28.9	16.5	20.3	x	34.3	x	x	x	25.4
S05-low	15.2	15.6	19.4	37.8	15.6	19.4	x	33.3	x	x	x	29.2
S06	x	12.1	21.0	27.3	x	10.8	34.6	41.3	x	10.5	29.8	36.2
S07	13.0	14.0	x	40.0	10.2	12.1	34.6	41.9	x	12.7	28.6	37.5
S08	x	x	x	23.5	x	x	x	28.9	x	x	x	21.0
S09	15.9	19.4	21.3	28.3	11.4	14.0	30.5	35.2	x	13.7	20.6	25.1
S10	14.6	19.1	21.0	27.6	10.8	13.7	30.8	35.9	x	14.0	20.3	25.7
S11-high	12.7	20.6	29.8	38.1	12.1	15.2	34.3	43.2	12.7	18.7	27.9	36.2
S11-low	13.3	21.0	30.5	38.7	12.7	15.6	34.9	42.9	12.7	19.1	26.7	34.9
S12-high	16.5	20.0	33.0	41.3	8.3	19.4	37.5	43.2	12.7	16.8	33.0	38.1
S12-low	15.2	18.1	32.4	41.3	10.2	19.1	37.5	43.2	15.9	16.5	33.0	38.1
S13	13.7	14.9	25.1	34.6	x	14.0	28.3	38.1	x	x	23.2	32.4
S14	12.7	23.5	x	30.2	x	28.6	x	34.0	x	19.1	x	26.0

Similar to the first comparison, products S01, S02, S09, and S10 indicate a close match with the exemplar product, with >80% of the measurements matching the product. Products S01, S09, and S10 matched all 12/12 measurements, indicating the soft goods of these products are substantially similar.

Finally, I made the following observations related to the design of the Fisher Price Rock ‘n Play Sleeper product:

1. Plastic surface underneath soft goods;
2. Removable soft goods;
3. Unusual shape of plastic surface; and
4. Deep seat / included angle.

My measurements and observations of the Fisher Price Rock ‘n Play Sleeper relate to the measurements and observations made on products S01, S09, and S10 as part of the CPSC study (See Appendix C, Table 4). Because of the many similarities in product measurements and qualitative observations, **it is my opinion that the Fisher Price Rock ‘n Play Sleeper inclined sleep product is functionally equivalent to products S01, S09, and S10 in the CPSC Study, which are from the same manufacturer who also manufactured S02**. Slight differences in measurements are likely attributed to variations in soft goods designs, which is a reasonable assumption considering the vast number of models Fisher Price manufactured which all feature similar designs. Figure 5 shows a number of individual inclined products that Fisher Price manufactured, all apparently featuring a similar underlying design with varying soft goods. In spite of the slight differences between products (manual rocking vs. auto rocking, soft goods, and deluxe vs. basic), **these products can be considered to be functionally equivalent from a mechanical standpoint**.

Figure 5. Screenshots of the recalled Rock ‘n Play Sleeper. Note the variations in soft goods designs, and manual-rocking vs. auto-rocking vs. vibrating designs. https://s.yimg.com/aah/albee-baby/fisher-price-newborn-rock-n-play-sleeper-animal-menagerie-143.jpg; https://www.businessinsider.com/fisher-price-rock-n-play-voucher-refund-2019-4; https://www.jolinaforuno.top/products.aspx?cname=fisher%2bprice%2bauto%2brock%2bn%2bplay%2bwalmart&cid=7. Accessed 02.13.2022.

5.2 Relevant Results from my CPSC *in vivo* Human Biomechanics Study

Because I have characterized the Fisher Price Rock ‘n Play Sleeper as functionally equivalent to products in the CPSC Study, **the conclusions related to the *in vivo* biomechanics study for this product apply to this specific case**. Product S02 was from the same manufacturer of products S01, S09, and S10, all reportedly different versions of the inclined sleep product, and was included in *in vivo* portion of the CPSC Study and my subsequent peer-reviewed publication (Wang et al., 2021).

Detailed methodology related to the *in vivo* biomechanics study is provided in the CPSC Study report (CPSC, 2019), as well as two peer-reviewed publications (Wang et al., 2020 and Wang et al., 2021). The main findings specifically related to products which are functionally equivalent to the Fisher Price Rock ‘n Play Sleeper are as follows:

Product

(1) The inclined sleeper is not functionally equivalent to a firm and flat crib mattress as evidenced by biomechanical differences between babies,

Supine-to-Supine Condition

(2) The number of trunk movements decreased significantly during supine lying compared to lying on a flat surface, indicating babies must use their neck/head to maneuver within the product resulting in a chin-to-chest position,
(3) Trunk flexion increased significantly in inclined sleep products compared to lying on a firm and flat crib mattress, indicating negative implications on breathing mechanics.

As discussed in detail above (section 3.2), these significant results are specifically applicable to the Fisher Price Rock ‘n Play Sleeper resulting in an altered body position with negative implications on breathing.

5.3 Product Conformity

Lengthwise Conformity

The design of the Fisher Price Rock 'n Play Sleeper cannot be considered firm nor flat, both due to the incline angle, and due to the soft conforming surface.

When a baby, who has a flexible spine, lays in the Fisher Price Rock 'n Play Sleeper product, there is not enough structural integrity of the soft goods on top of the plastic support, meaning the product conforms to the baby rather than providing a firm and flat support like the AAP recommends. His or her back and neck will not be fully extended in the same way that it is on a firm and flat surface like a crib mattress. Instead, the baby's spine (the neck and/or the trunk) will flex, meaning the baby will be experiencing a seated, slouched position with his or her head flexed toward the chest. Additionally, based on the placement and the size of the child, the degree of spinal curvature could change.

Widthwise Conformity

On a firm flat surface like a crib mattress, when a baby rotates his or her head to the side by 90 degrees, there is nothing directly near the mouth or nose to obstruct breathing. This is not the case in the Fisher Price Rock 'n Play Sleeper product. To illustrate this fact, I took radial measurements of the product near the head region without the soft goods in place (Figure 6A), with soft goods covering the plastic surface at 6.5 cm depth representing half of Avery's head diameter, showing a 13.5 cm width (Figure 6B). To illustrate the fact that normal head rotation within the product creates a dangerous scenario, I used a child's inflatable ball with a circumference of 41 cm (the same circumference of Avery's head) to illustrate the dangers of the product. The purple piece of paper represents the mouth and nose region, with Figure 6C representing a face up supine position. At a normal 90-degree head turn, the baby's mouth and nose would be in direct contact with the soft goods covering the solid plastic support piece, *not* the mesh sides, as shown in Figure 6D. Figure 6E shows my fingers touching the portion of the product where the plastic surface ends, meaning that Avery's face was in contact with the soft goods covering the impermeable plastic surface with a 90-degree head turn.

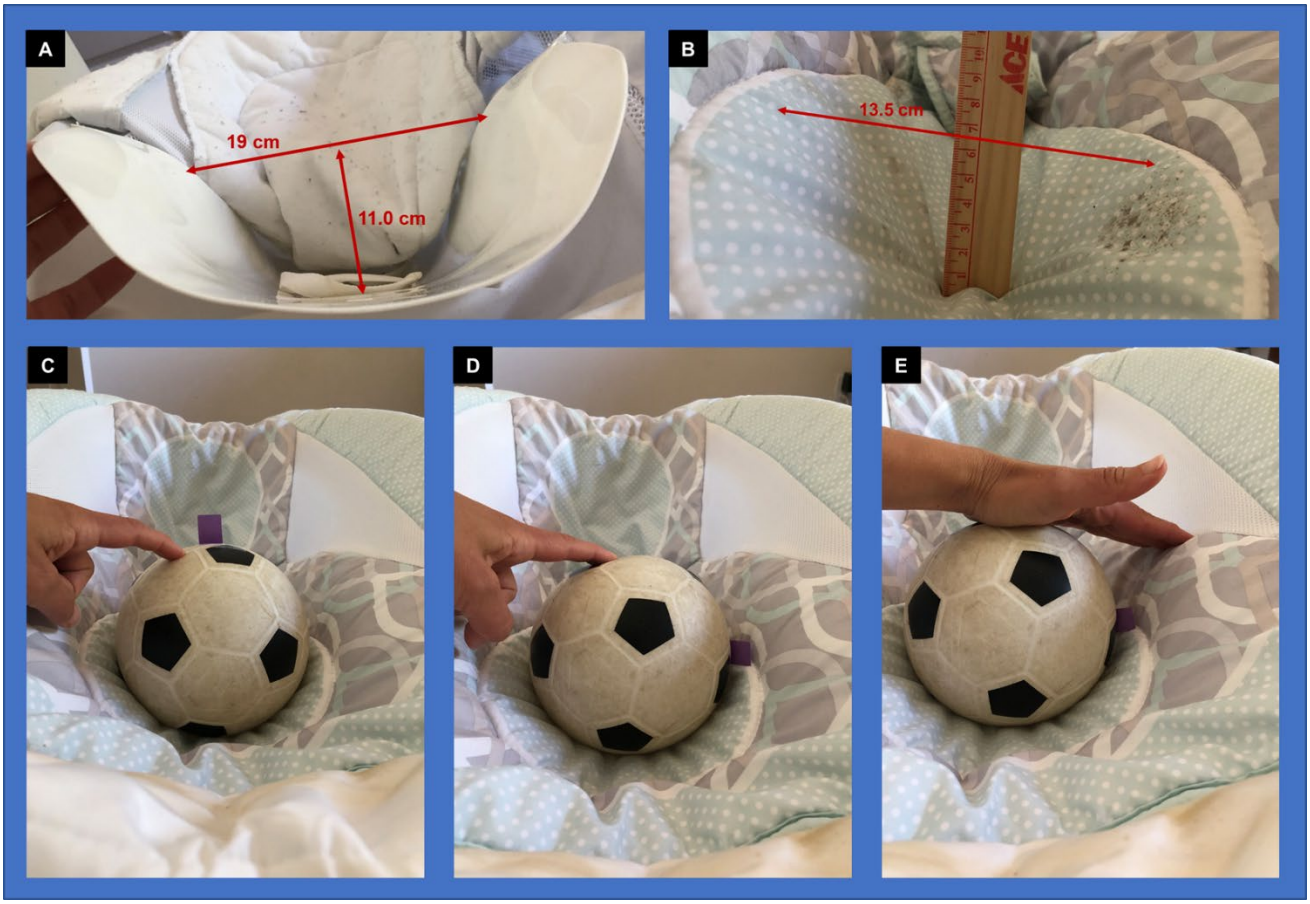

Figure 6: Photos showing the curvature of the plastic surface of the Fisher Price Rock 'n Play Sleeper near the head area: (A) shows the product without the soft goods correctly in place, (B) shows the product with the soft goods in place and a ruler showing the depth, (C)

Using a simple schematic, I used the diameter of [redacted] Kelley's head (approximately 13.1 cm) to further show the orientation of her head within the product (Figure 7). I again found that with perfectly centered placement within the product, if [redacted] Kelley's head was turned 90-degrees that her nose and mouth would be in direct contact with the soft goods covering the plastic support piece (Figure 7B), *not* the mesh sides, agreeing with the photos I took in the product in Figure 6. Compared to the flat surface depiction in Figure 6C where nothing is obstructing breathing when an infant turns her head 90 degrees, the Fisher Price Rock 'n Play Sleeper configuration has especially concerning implications for CO_2 rebreathing and suffocation due to mouth or nose occlusion. This conservative model also does not account for the deformation that occurs in soft goods with the application of force, meaning that the soft goods

would be even closer to the mouth/nose region as the head causes material deformation at the load site.

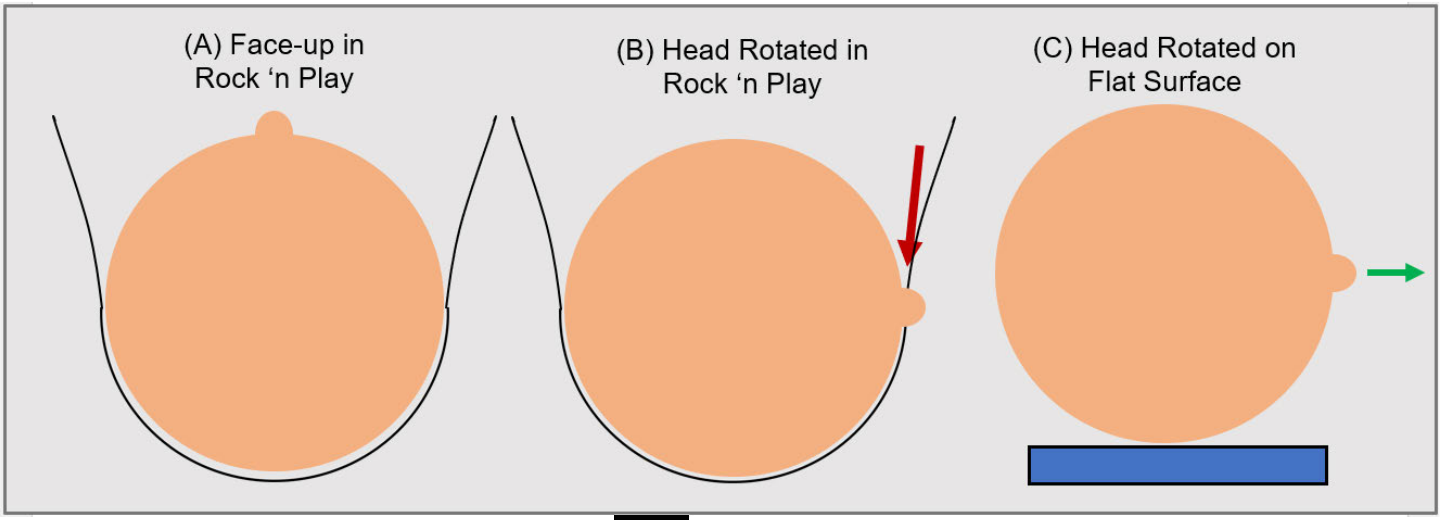

Figure 7. Representative drawing of [redacted] Kelley’s 13.1 cm diameter head lying (A) in the Fisher Price Rock ‘n Play Sleeper depicting a face up position; (B) in the Fisher Price Rock ‘n Play Sleeper depicting a 90 degree head rotation where the red arrow shows her nose would be in contact with the plush side of the product; and (C) on a firm and flat surface like a crib mattress, where the green arrow shows no breathing obstructions.

I also noted the unusual curvature of the plastic support piece as depicted in Figure 6. The curvature of the plastic surface from the new product compared to my personally owned, previously-used product appears different than the photos and drawings I observed in the documentation regarding the design of the product and in online photos of new Fisher Price Rock ‘n Play products. This brings into question if material property changes over time or due to storage or weather were considered by Fisher Price. It is well-known that many plastics degrade or deform over time due to a combination of environmental factors or mechanical force. For example, the car seat industry recognizes that plastic degradation from environmental changes can result in mechanical changes to the material, making the product unsafe for its intended use in a crash situation. Therefore, car seats feature an expiration date. From my understanding, Fisher Price did not adequately consider how instructed storage (e.g., folded up and stored leaning on its side) or environmental changes (e.g., storage in an attic or basement which may experience extreme heat/humidity and/or extreme cold) would change the fundamental design of their product because there are limited instructions related to storage of product. I own the exemplar Fisher Price Rock ‘n Play product and confirm that it has been stored on my property, folded up and

leaning against a wall since I acquired it in used condition, in 2021. However, I note that the apparent deformation of the plastic support piece in my exemplar unit could have been different the in product that [redacted] died in; there is no way for me to know for certain. The product does not have an expiration date to consider.

5.4 Review of Fisher Price Observations and Testing

From my review of the documents I was provided and the depositions, Fisher Price had several separate formal engagements with consultants related to how the design of the Rock ‘n Play Sleeper may impact a baby’s biomechanics (body position and/or ability to move within the product): (1) Dr. Deegear’s product observations prior to the product release, (2) in-home questionnaires with parents prior to release, (3) play-lab observations prior to the release, and (4) observations with commentary provided by Drs. Fox and Shaffer and Exponent several years after the product had been released in response to litigation. From my understanding, none of the individuals involved in designing any of these experiments, conducting the experiments, or analyzing the data, have advanced degrees in engineering with peer-reviewed research in infant biomechanics. The observational techniques used in these four scenarios were not biomechanical analyses which would stand up to the rigor of the current state of the art, or even the state of the art from the 1980s. The research I conducted as part of my 2019 CPSC study used gold standard biomechanics techniques to evaluate body position and muscle activity of babies, and the studies have since been peer-reviewed and published in the Journal of Biomechanics. None of the observations or testing sessions done by Fisher Price or its consultants used well-accepted methodology or analyses which would be considered “biomechanics” studies or analyses by an expert in the field.

6. Biomechanical Engineering Conclusions

After review of the above information, I can offer the following conclusions to a reasonable degree of biomechanical engineering certainty:

1. The Fisher Price Rock ‘n Play Sleeper product involved in [redacted] Kelley’s incident is an inclined sleep product.
2. The Fisher Price Rock ‘n Play Sleeper product has measurements and characteristics consistent with products S01, S09, and S10 which were included in my 2018-2019 U.S. CPSC Inclined Sleep Products Biomechanics Study. Because the Fisher Price Rock ‘n Play Sleeper product is functionally equivalent to products in my study, the data from products S01 and S02 which were included in the human subjects biomechanics research as part of the CPSC study and S02 in my subsequent peer-reviewed research can be reliably used to understand how a baby would move and use their muscles in the Fisher Price Rock ‘n Play Sleeper product.
3. Based on the results of my CPSC study, my subsequent peer-reviewed research (CPSC, 2019; Wang 2021), and my inspection of the product in this case, the design of the Fisher Price Rock ‘n Play Sleeper results in a flexed trunk posture during supine lying, a position which inhibits normal breathing based on medical literature.
4. The Fisher Price Rock ‘n Play Sleeper is not a firm nor a flat product and is inconsistent with the sleep recommendations of the American Academy of Pediatrics.
5. The design of the Fisher Price Rock ‘n Play Sleeper product lacks a firm support and features significant concavity, which enabled [redacted] Kelley’s face to easily be in contact or in close contact with the solid soft goods covering the solid plastic surface in the side of the product. This design results in a dangerous CO_2 rebreathing and/or suffocation scenario.
6. The design of the Fisher Price Rock ‘n Play Sleeper product promoted a flexed trunk position for [redacted] Kelley, which compromised her respiration and could have led to positional asphyxia.
7. The plastic surface apparently experienced deformation which made the product even more unsafe than the original design. From my review, Fisher Price did not provide users with an expiration date or adequate storage advice to avoid the plastic degradation and deformation.
8. Fisher Price did not consult with a biomechanical engineer nor pediatrician during the development of the Fisher Price Rock ‘n Play Sleeper product or any of their inclined sleep products.

9. Methods used to conduct my biomechanical analysis of babies in inclined sleep products could have been done by biomechanical experts before the release of the product in 2009.
10. If asked to consult on the design of the Fisher Price Rock ‘n Play Sleeper product or other Fisher Price inclined sleeper designs, in my opinion, a biomechanical engineer would have recommended against any design that places an infant in an inclined position with a concave surface, which is what I would have reported if consulted at the time.
11. It is my opinion that the design of the Fisher Price Rock ‘n Play Sleeper resulted in a dangerous biomechanical position that can cause suffocation, like in the case of [redacted] Kelley.

Should further information become available, I reserve the right to amend or supplement this report at that time.

Erin M. Mannen, Ph.D.

7. Other Expert Witness Trials or Depositions

I have not served as an expert witness in any trials or depositions in the past four years.

8. Compensation

My hourly rate for the study and testimony in this case was $500/hour.

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Appendix A: *Peer-Reviewed Publications in Scientific Journals over the Past 10 Years.*

PEER-REVIEWED JOURNAL PUBLICATIONS

*EM Mannen Corresponding/Senior Author

‡Mentored Student/Resident/Postdoctoral Fellow

2022

1. *Sherrill JT‡, Bumpass DB, **Mannen EM**. Mechanical Analysis of 3 Posterior Fusion Assemblies Intended to Cross the Cervicothoracic Junction. *Clinical Spine Surgery.* 2022 Apr 6. doi: 10.1097/BSD.0000000000001317. Epub ahead of print. PMID: 35383602.
2. Kefala V, Ali AA, Hamilton LD, **Mannen EM**, Shelburne KB. Effects of Weightbearing on Tibiofemoral, Patellofemoral, and Patellar Tendon Kinematics in Older Adults. *Frontiers in Bioengineering and Biotechnology, section Biomechanics.* 2022 April 14. doi: 10.3389/fbioe.2022.820196.
3. Wang J‡, Latt LD, Martin RD, **Mannen EM**. Postural Control Differences between Patients with Posterior Tibial Tendon Dysfunction and Healthy People during Gait. I*nternational Journal of Environmental Research and Public Health.* 2022 Jan 24;19(3):1301. doi: 10.3390/ijerph19031301. PMID: 35162324; PMCID: PMC8835140.

2021

4. *Wang J‡, Siddicky SF‡, Carroll CJ, Rabenhorst BM, Bumpass DB, Whitaker BN, **Mannen EM.** Infant inclined sleep product safety: A model for using biomechanics to explore safe infant product design. *Journal of Biomechanics*. 2021 Nov 9;128:110706. doi: 10.1016/j.jbiomech.2021.110706. Epub 2021 Aug 28. PMID: 34624615.
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8. Wang J‡, Siddicky SF‡, Severin AC‡, Barnes CL, **Mannen EM**. "Effect of movement speed on lower and upper body biomechanics during sit-to-stand-to-sit transfers: self-selected speed vs. fast imposed speed," *Human Movement Science*. Accepted April 2021, *in press.*
9. *Wang J‡, Siddicky SF‡, Johnson T, Kapil N, Majmudar B, **Mannen EM**. "Supine lying center of pressure characteristics as a predictor of developmental stages in early infancy," *Technology and Health Care.* Accepted February 2021. Online ahead of print. doi: 10.3233/THC-202754; PMID: 33998566
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17. *Wang J‡, Siddicky SF‡, Carroll JL, Rabenhorst BM, Bumpass DB, Whitaker BN, **Mannen EM**. "Do inclined sleep surfaces impact infants' muscle activity and movement? A safe sleep product design perspective," *Journal of Biomechanics*. Oct 9;111:109999. Epub 2020 Aug 17.
doi: 10.1016/j.jbiomech.2020.109999. PMID: 32862027
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Appendix B: *In-Depth Investigation Analysis from U.S. CPSC Study*

This section is directly from the U.S. CPSC report of the in-depth investigation analysis methods and summary conducted by my team and me (U.S. CPSC, 2019).

2. INCIDENT REPORT ANALYSIS

2.1 Incident Report Methods

The CPSC provided the research team with details of incidents involving Inclined Sleep Products. At the time of this report (July 2019), there were 91 separate incidents reported to or investigated by the CPSC involving an incident (hazard, injury, or death). Varying amounts of information were provided for each incident, including police reports, coroner reports, witness statements, photos, videos, and summaries of the event written by CPSC employees. The summaries written by the CPSC were not considered in this qualitative analysis.

Each incident was reviewed by two members of the research team, separately confirming details of the events. The following data was gathered from the reports and organized in a spreadsheet: date of incident, incident (hazard, injury, or death), manufacturer and model, city and state, infant demographics at time of incident (age, sex, race/ethnicity, height, weight), incident details (initial position, found position, time since last checked, found by, restraint used, soft goods found with infant, other items found with infant, room temperature, current medical conditions, usual sleeping position, other notes), birth and pregnancy details (pregnancy concerns, gestational age, maternal age, paternal age, Apgar Score, height, weight, previous medical history), coroner report details (medical findings, cause of death, manner of death, medical notes), conflicting details noted by the team, and other notes of interest.

The incidents were sorted into the following six categories with descriptions:

- *Supine-supine*: infant was placed in a supine position and found in a supine position.
- *Supine-prone*: infant was placed in a supine position and found in a prone or side-lying position.
- *Supine-other*: infant was placed in a supine position and found in a sitting position, was hanging from the product, or had fallen out of the product.
- *Prone-prone*: infant was placed in a prone position and found in a prone position.
- *Other circumstances*: external circumstances not related to the product caused the incident.
- *Not enough information*: reports do not have enough information to determine event; there were no witness statements, detailed description of the event, police report, hospital records, or medical records included in these incidents.

Because some incident reports were incomplete or contained conflicting details regarding initial and found positions, extra attention was given to these incidents to categorize them as accurately as possible. For instance, if autopsy or police investigative evidence supported that the found position was different than initially reported by the caregivers (i.e. location of lividity in autopsy reports), the categorization was based on an evaluation of all information available for that incident.

Descriptive qualitative analysis of each of these incident categories was provided, with the biomechanists and pediatric orthopaedists focusing on the movement-based incidents (*supine-prone, supine-other)*, and the biomechanists and pediatric pulmonologist focusing on the *supine-supine* and *prone-prone* categories. Student's t-tests (p=0.05) were used to compare average ages of infants who experienced *supine-supine* v. *supine-prone* events. Reference to specific product manufacturers or designs has been blinded from the main portion of this report, so companies are referred to as "Company A, Company B," etc. Similarly, the products are coded as "S01, S02," etc. The key for company and product codes can be found in Appendix C.

2.2 Incident Report Results

All 91 incidents were reviewed and sorted into the following categories described in section 2.4:

- ***Supine-supine***: 38 [Company A (products S01 and S02); Company B (products S03 and S06)]. Of these, 33 were deaths, 4 were injuries, and 1 was a hazardous event.
- ***Supine-prone***: 25 [Company A (products S01 and S02); Company B (products S03 and S06); Company C (product S08)]. Of these, 21 were deaths and 4 were injuries.
- ***Supine-other***: 4 [Company A (product S01)]. Of these, 2 were injuries and 2 were hazardous events.
- ***Prone-prone:*** 3 [Company A (products S01 and S02)]. All 3 of these incidents were deaths.
- ***Other circumstances***: 2 [Company A (products S01 and S02)].
- ***Not enough information***: 19 [Company A (products S01 and S02)].

Detailed summaries of all incidents are provided in Appendix D.

The ***Other circumstances*** category included incidents where external circumstances not related to the product caused the event. Both cases were deaths. These two events are not under consideration as incidents that may have been caused by the inclined sleep products.

After eliminating the two incidents from the ***Other circumstances*** category, 89 events were left to analyze. Nineteen incidents were categorized as ***Not enough information***. If incidents did not contain police reports or interviews, medical records, descriptive information regarding the event, or autopsy/coroner's reports, they were considered in this ***Not enough information*** category. Two of these incidents (1 death, 1 injury) were reported to the CPSC or found via internet research but attempts by the CPSC for follow-up communication were unsuccessful. Of the remaining 17 events, 14 were deaths and 3 were injuries. Most of these incidents were reported to or discovered by the CPSC after the April 2019 voluntary recall of two companies' inclined sleep products. Therefore, many of the CPSC investigations are ongoing. It is expected that many of these events will eventually fall into either the ***supine-supine***, ***supine-prone***, ***supine-other***, *or* ***prone-prone*** categories after in-depth investigations have been completed, but there is not enough information to be certain at the time of this report.

After excluding the 19 incidents from the ***Not enough information*** category, 70 events remained. The ***supine-supine***, ***supine-prone***, ***supine-other***, *and* ***prone-prone*** events were considered the highest priority in analyzing and understanding the circumstances surrounding the events, therefore these categories were examined in more detail.

Figure 1 shows a map of the continental United States with pins placed at the locations of each ***supine-supine***, ***supine-prone***, ***supine-other***, *or* ***prone-prone*** incident, and colors indicate the event (blue-death; orange-injury; green-hazard). Events occurred in 29 states throughout the country.

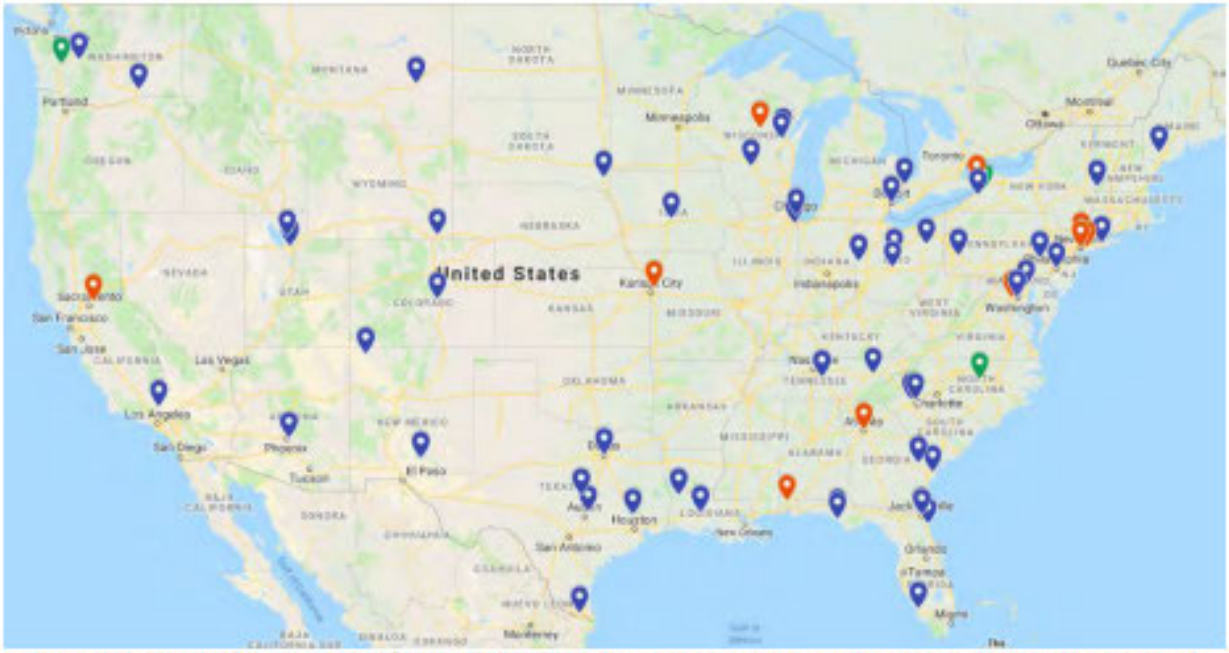


Figure 1. Map of the United States showing *supine-supine*, *supine-prone*, *prone-prone*, and *supine-other* incidents related to inclined sleep products reported to and investigated by the CPSC. Blue-death; orange-injury; green-hazard.

Supine-Supine Events

There were 38 ***supine-supine*** events reported and investigated between 2011 to 2019. Of these, 33 resulted in death, 4 resulted in injury, and 1 was a hazard. Events occurred in products from Companies A and B, with basic (S01 and S03) and deluxe (S02 and S06) versions of their inclined sleep products. Sex distribution was 20 males and 18 females. Racial/ethnicity distribution was 23 White, 5 Black, 3 Hispanic, and 7 Not Reported. The average age of the infants at the time of the event was 3.2±2.3 months (adjusted age 3.0±2.3 months). Six infants were reportedly born pre-term (<37 weeks gestation).

The incidents in which a death occurred when an infant was placed supine and found supine show a few notable trends. First, 10/33 (30%) of the deaths occurred in infants who were currently sick with colds, respiratory symptoms, or fevers. Upon further review, 4/33 (12%) of infant deaths occurred in infants with significant health problems or chronic health issues. Four reports indicated smoking in the home, and all of these were of infants who were currently sick or chronically ill. A pediatric pulmonologist determined that 4/33 (12%) of the deaths are likely attributed to health issues not necessarily caused by the sleeping position. While only a few incidents specifically indicated a "chin-to-chest" position, the deaths or injuries may have been related to either a chin-to-chest position that restricted airflow, and/or carbon dioxide rebreathing from contact or near-contact of the infants' faces to the sides of the products, a position that was commonly noted in the police reports in the in-depth investigations. However, no further analyses on these incidents nor on the chin-to-chest position were performed, so the impact of the chin-to-chest position in inclined sleep products is unknown. In addition, many of the reports indicate the parents utilized an inclined sleep product on the recommendation of a medical professional or friend to aid with either respiratory sickness or reflux, though this recommendation is not supported with evidence-based research. Of the infants who were not suffering from a chronic health condition or temporary illness at the time of the death, four were sick within the last month. 6/33 (18%) of infants who died were born premature. Two reports indicated the inclined sleep product was not the infant's

regular sleeping surface, but most reports had missing information regarding normal sleeping position. Several infants were placed supine with their lower extremities swaddled and their upper extremities free to move. Twelve infants were reportedly not buckled into the product, while six were initially buckled, with many reports not listing the information. No significant trends were found regarding other demographic or situational data, partly due to incomplete reports across the many categories.

Positional asphyxiation is the most likely cause of death for most of the infants in the ***supine-supine*** group, particularly when considering most of the products were "deluxe" versions (S02 and S06) which feature very heavy padding with a pillow-like headrest. It is likely that infants' noses and mouths were too close to the side of the product, resulting in reduced airflow and carbon dioxide rebreathing, leading to their demise. This is further supported by the number of infants who had blood and/or mucus on their noses or mouths when they were found. Nasal hemorrhaging is associated with suffocation in infant deaths (Bercroft et al., 2001), and the presence of blood noted in these reports supports suffocation as the cause of death. However, no breathability analysis was conducted as a part of this study, so it cannot conclusively be stated that the material or design of the product promoted carbon dioxide rebreathing or suffocation based on the incident analyses.

Supine-Prone Events

There were 25 ***supine-prone*** events reported and investigated between 2010 and 2019. Of the 25 events, 21 resulted in death and 4 resulted in injury. Events occurred in products from Companies A, B, and C, with basic (S01 and S03) and deluxe (S02 and S06) inclined sleep products, and product S08 which was sold as a stand-alone sleep product in a larger set by Company C. Sex distribution was 15 males and 10 females. Racial and ethnicity distribution was 15 White, 2 Black, 1 Hispanic, 2 Other, and 5 Not Reported. The average age of the infants at the time of the event was 4.2±1.8 months (adjusted age 4.0±2.1 months), 1.0 months older than the age of infants who experienced supine-supine events ($p=0.081$). One infant was reportedly born pre-term (<37 weeks gestation).

Similar to the *supine-supine* incident analysis, the incidents in which a death occurred when an infant was placed supine and found prone show a few notable trends. First, 4/21 (19%) of the deaths occurred in infants who were currently sick with colds, respiratory symptoms (at least moderate congestion), or fevers. No deaths occurred in infants with significant health problems or chronic health issues. Of the infants who were not suffering from a temporary illness at the time of the death, three were sick within the last month, and five others had findings during the autopsy that indicated mild lung congestion. 1/21 (5%) of infants who died was born premature. A few reports specifically mentioned that the baby had never before rolled unassisted, but most investigations did not contain this information. Similarly, though many reports did not have the information, five parents indicated the inclined sleep product was not the infant's typical sleeping environment, with one mother stating the infant died the first time the product was used. Nine infants who died were reportedly not buckled into the product, while one was initially buckled, with eleven reports not listing the information. In many of the incidents, the babies were found with their faces in direct contact with the surface, the "pillow" portion, or the seat portion of the inclined sleep product. In the incident where the infant was reportedly initially buckled, it was noted that the caregiver found the infant with the feet in the seat portion of the inclined sleep product, in a "standing" type of prone-lying position within the product. No significant trends were found regarding other demographic or situational data, partly due to incomplete reports across the many categories.

In the United States, it is recommended that infants are put to sleep on their backs, partly based on previous research indicating prone sleeping results in lower oxygen saturation levels in babies (Galland et al., 2000), especially premature babies (Smith et al., 2010). Other peer-reviewed research indicates that at 4 months old, 40% of infants who sleep supine are able to roll (Jantz et al., 1997), with 80% of infants rolling prior to six months of age (Benjamin Neelon et al., 2016). One study reports the age of rolling from front-to-back-to-front is just under six months (Ertem et al., 2018). Once an infant is able to roll on his/her own, the risk of suffocation from prone sleeping may decrease as the infant has increased motor control and has a greater ability to reposition themselves to avoid suffocation. In fact, once an infant is able to roll from supine to prone and prone to supine unassisted, parents are told by the AAP to continue to place the infant to sleep on their backs until 1 year of age, but not to worry or reposition the baby back to supine if the baby rolls to prone on their own during sleep (Moon et al., 2016). This logic likely does not translate to the inclined sleep products because the environment is so different compared to a flat crib mattress. Additionally, other researchers report that the most common risk factor for sleep-related deaths in 4 to 12 month old infants is rolling into other objects in their sleep area such as crib bumpers or pillows (Colvin et al., 2014). This again raises concerns with the inclined sleep products, as the surface is not the same as a crib mattress and often features heavy padding similar to crib bumpers and headrests that are similar to small pillows.

The average age of the infants in these ***supine-prone*** incidents who experienced events of rolling from supine to prone in an inclined sleep product was 4.2 months (approximately 1.5 months less than average front-to-back-to-front rolling age, Ertem et al., 2018), and many of the reports include statements that the parents had never observed the infant roll on his/her own. It is likely that if an infant experiences a supine to prone roll for the first time in an inclined sleep product, that the baby is put in a position he/she has never before experienced: prone in a non-rigid, concave, and/or heavily padded inclined sleep product. The biomechanical analysis (Section 4) explores these ideas further.

Supine-Other Events

There were four ***supine-other*** events reported and investigated between 2011 and 2013. Two events were injuries and two were hazards. Events occurred in basic products (S01) from Company A. Sex distribution was two males and two females. Racial and ethnicity distribution was 1 White, 1 Other, and 2 Not Reported. The average age of the infants at the time of the events was 7.0±3.4 months. Restraints were reportedly used in three of the four events (75%). No information on prematurity or health was reported in these events.

These four ***supine-other*** incidents occurred in infants aged 5 months to 12 months, an older cohort than the other categories. In two incidents, caregivers reported that infants were able to climb out of the product, even when buckled into the harness. One infant was found sitting backwards in the product. In the remaining incident, the infant was found hanging from the product with her leg caught in the harness straps. These four incidents describe events in which babies have maneuvered within or out of the inclined sleep products, resulting in unintended and hazardous positions. A fall from the product to the floor presents a risk of injury for the infant. The incident describing the infant's leg caught in the product presents a risk of serious injury if circulation is cut off for too long; pain and muscle damage are potential outcomes. These events highlight a unique set of risks that are likely specific for older infants who are able to significantly maneuver within or out of the inclined sleep products

Prone-Prone Events

There were three ***prone-prone*** events reported and investigated between 2013 and 2017. All three events resulted in deaths. Events occurred in products from Company A basic (S01) and

deluxe (S02) inclined sleep products. All three infants were female. Racial and ethnicity distribution was 2 Black and 1 Hispanic. The average age of the infants at the time of the event was 2.3±2.1 months (adjusted age 1.9±2.3 months). One infant was reportedly born pre-term (<37 weeks gestation). At the time of the incidents, one infant was healthy, one was sick, and one was chronically ill. Two parents reported that no restraint was used. While instructions on inclined sleep products indicate that infants should be placed in the supine position, it is clear from these three incidents that those instructions are not always followed by caregivers. The biomechanical analysis (Section 4) will further explore the implications of the prone position in inclined sleep products.

Incident Report Summary

Ninety-one reported incidents of deaths, injuries, and hazards occurred in inclined sleep products from 2010 to 2019. Most incidents fell into two main categories: *supine-supine* and *supine-prone*. The *supine-supine* events occurred in younger infants (average 3.2 months), and many were currently sick, suffering from chronic conditions, or born prematurely. Many reportedly were found with their faces in contact with the sides of the product, and several had blood or mucus on their nose and mouth when they were found, suggesting suffocation as a cause of death. The *supine-prone* events occurred in older infants (average 4.2 months), and sickness, chronic conditions, and prematurity were less prevalent compared to the *supine-supine* events. The three-point harness was used in at least one *supine-prone* event and three of the four *supine-other* events, and many reports indicated that the infant had not been observed to roll alone prior to the incident.

Appendix C: *Product Analysis from U.S. CPSC Study*

This section is directly from the U.S. CPSC report of the product analysis methods and results conducted by my team on 14 inclined sleep products (U.S. CPSC, 2019). I used these methods to evaluate the Fisher Price Rock ‘n Play Sleeper. The measurement techniques used are detailed in ASTM F3118-17a: Standard Consumer Safety Specification for Infant Inclined Sleep Products. This specific use in characterizing inclined sleep products was subsequently published in the peer-reviewed *Journal of Biomechanics* as part of Wang et. al, 2021.

3. PRODUCT ANALYSIS

3.1 Overview

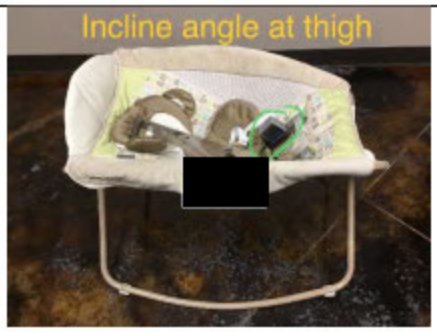
The CPSC provided the research team with 14 different unassembled products that fell into the category of "Inclined Sleep Product." Most products were frame-type products that were sold alone, but one product (S08) was sold as a part of a set of infant products. Each product was assembled by the research team according to the instructions and was thoroughly examined to ensure no product damage was present.

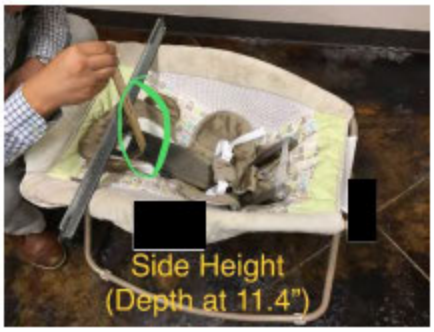
Each of the 14 inclined sleep products were analyzed and measured using methodology from ASTM F3118-17a: Standard Consumer Safety Specification for Infant Inclined Sleep Products. The research team also identified additional differences in products, and therefore added other measurements as needed. Below is a table of the Measurement, Procedure, and corresponding Photos used to obtain each measurement. A hinged weight gauge infant was also provided by the CPSC. The research team measured and analyzed it to ensure it met the appropriate dimensions prior to using it for measurements.

3.2 Measurement Procedures

Table 1 details the measurements taken for each of the 14 inclined sleep products. Some products allowed for different incline settings, so measurements were taken at both the highest and the lowest settings.

Table 1: Measurements with detailed procedures and photos in a representative inclined sleep product.

Measurement	Procedure	Photos
Minimum Incline at Head	7.10* = Hinged weight gauge-infant centered in product with hinge centered over seat bight line, upper plate on seat back surface. Digital protractor placed (centered) on upper plate to measure top surface seat back angle relative to horizontal.	
Maximum Incline at Head	7.11* = If applicable, repeated with manufacturer's recommended highest incline position	
Minimum Incline at Thigh	Placed as above, for lower plate, to get thigh angle	
Maximum Incline at Thigh	As above, repeated with manufacturer's recommended highest incline position	

Side height (Depth at 11.4")	7.12* = Reference line made at 11.4" from hinge on upper plate. Center point of this reference mark also made. Straight edge with length greater than product width laid across product "rails"/"top", second straight edge placed vertically upwards from reference mark to ensure orthogonal measurement. Vertical distance (d) between underside of straight edge and the upper surface of the hinged weight gauge-infant measured with measuring tape. (Fig. 12, page 13)*	
Usable length (Hinge, to top of backing seam, where the head sits)	7.15* = Hinged weight gauge-infant centered in product with hinge centered over seat bight line, upper plate on seat back surface. Measured, using a tape measure, the distance from intersection of gage plates to top edge of head containment area (top seam above which the head cannot be positioned)	
Width at Shoulder (at 11.4")	Start of additional measurements. Straight edge with length greater than product width laid across product "rails"/"top", second straight edge placed vertically upwards from reference mark to ensure orthogonal measurement. Width of product at this point measured with tape measure	
Width at Hinge	As above, repeated at intersection of upper and lower plate (hinge)	

Width at Knee	As above, repeated at bottom of lower plate	
Maximum Width	Tape measure used to measure maximum width of product (excluding attachments such as electronics or mobile)	
Minimum Width	As above	

Minimum Incline (w/Rock)	Digital protractor placed (centered) on upper plate to measure top surface seat back angle relative to horizontal. Minimum incline w/rock was defined as the angle displayed on protractor with maximum rock/tilt towards head end	
Maximum Incline (w/Rock)	As above, with maximum tilt/rock towards foot end	
Curved / Thick Plastic Molding? (Y/N)	Whether the product had curved/thick plastic molding underneath the surface and/or seat	
Thin Plastic Molding? (Y/N)	As above, but whether the material was a thin deformable plastic	
Side Mesh? (Y/N)	Whether there was side mesh (3.1.9)*	
Plastic	For Reference line (11.4 from hinge), Hinge, and Bottom of lower plate, measurements made along the surface parallel to reference line. This measure is from the center line on the reference line to the "edge" of the plastic molding (if any)	

Solid	From the center line to the end/edge of the solid "fabric"	
Mesh	From the center line to the end/edge of the mesh (if any)	
End	From the center line to the end/edge of the product, i.e. up to the rail	

*These refer to Sections of ASTM F3118-17a: Standard Consumer Safety Specification for Infant Inclined Sleep Products

The results of the product analysis from the CPSC study follow, broken down into Table 2: Sample measurements and characteristics, Table 3: Distance of different materials on samples from the center at three locations, and Table 4: Sample measurement notes. Details related to these tables can be found in the original published CPSC study (CPSC, 2019).

Table 2. Sample measurements and characteristics

Sample	Minimum Incline @ Head (deg)	Maximum Incline @ Head (deg)	Thigh Angle @ Minimum Incline (deg)	Thigh Angle @ Maximum Incline (deg)	Side height (Depth at 11.4") (cm)	Usable length (Hinge, to top of backing seam/ head location) (cm)	Width at Shoulder (at 11.4") (cm)	Width at Hinge (cm)	Width at Knee (cm)	Maximum Width (cm)	Minimum Width (cm)	Minimum Incline (w/Rock) (deg)	Maximum Incline (w/Rock) (deg)	Curved / Thick Plastic Molding? (Y/N)	Thin Plastic molding? (Y/N)	Side Mesh? (Y/N)
S01	27.7	x	44.5	x	13.3	43.2	46.7	43.5	37.1	46.7	32.1	26.2	36.5	Y	N	Y
S02	24.4	x	51.7	x	14.0	45.1	47.3	16.8	38.7	51.8	32.4	23.0	31.7	Y	N	Y
S03	25.5	x	24.3	x	17.1	43.5	39.7	39.7	38.7	41.0	34.0	x	x	N	N	Y
S04	26.0	x	23.9	x	15.6	41.6	40.0	40.6	39.1	40.6	34.3	x	x	N	N	Y
S05-high	12.2	38.7	4.4	1.1	6.7	42.2	34.3	36.8	32.4	36.5	27.9	34.0	41.9	Y	N	Y
S05-low	x	x	x	x	20.0	39.4	30.2	35.6	32.4	x	x	10.7	18.3	x	x	x
S06	31.1	x	22.0	x	11.7	39.4	41.6	43.2	40.6	43.8	30.2	29.1	35.6	N	N	Y
S07	9.3	x	24.5	x	25.1	42.5	51.8	48.6	41.0	51.8	30.2	4.2	15.0	Y	N	Y
S08	31.3	x	38.2	x	3.8	43.5	42.9	40.6	35.2	41.9	18.4	29.8	36.4	N	N	N
S09	20.9	x	52.1	x	14.6	43.5	45.1	43.2	37.8	45.4	31.4	18.8	26.8	Y	N	Y
S10	25.7	x	52.6	x	13.7	44.5	44.5	43.2	38.1	44.5	31.1	24.7	30.0	Y	N	Y
S11-high	11.8	20.5	31.4	22.9	22.2	39.4	50.5	47.3	42.2	51.4	35.6	14.3	17.1	N	Y	Y
S11-low	x	x	x	x	21.9	40.0	49.8	48.9	42.2	x	x	20.3	22.4	x	x	x
S12-high	11.7	25.7	29.0	21.7	23.2	43.5	47.0	46.4	45.1	48.3	22.9	x	x	Y	N	Y
S12-low	x	x	x	x	26.0	43.5	47.3	46.0	43.5	x	x	x	x	x	x	x
S13	21.5	x	25.9	x	14.8	40.0	47.3	43.2	40.6	48.9	41.3	16.8	29.0	Y	N	Y
S14	16.9	x	44.2	x	11.4	44.1	48.3	48.6	43.2	48.9	38.1	10.8	20.6	Y	N	N

Table 3. Distance of different materials on samples from the center, at three locations

Sample	at 11.4"				at hinge				at knee			
	Plastic (cm)	Solid (cm)	Mesh (cm)	End (cm)	Plastic (cm)	Solid (cm)	Mesh (cm)	End (cm)	Plastic (cm)	Solid (cm)	Mesh (cm)	End (cm)
S01	15.2	16.5	22.2	29.2	12.7	14.0	30.8	39.1	x	13.0	21.3	27.9
S02	15.9	19.4	22.2	29.2	12.1	14.9	31.8	38.7	x	14.0	21.6	27.3
S03	x	12.1	24.1	29.2	x	11.1	x	39.4	x	12.7	x	34.9
S04	x	13.0	24.1	29.5	x	11.4	34.0	40.6	x	10.8	28.9	34.9
S05-high	15.2	17.1	20.3	28.9	16.5	20.3	x	34.3	x	x	x	25.4
S05-low	15.2	15.6	19.4	37.8	15.6	19.4	x	33.3	x	x	x	29.2
S06	x	12.1	21.0	27.3	x	10.8	34.6	41.3	x	10.5	29.8	36.2
S07	13.0	14.0	x	40.0	10.2	12.1	34.6	41.9	x	12.7	28.6	37.5
S08	x	x	x	23.5	x	x	x	28.9	x	x	x	21.0
S09	15.9	19.4	21.3	28.3	11.4	14.0	30.5	35.2	x	13.7	20.6	25.1
S10	14.6	19.1	21.0	27.6	10.8	13.7	30.8	35.9	x	14.0	20.3	25.7
S11-high	12.7	20.6	29.8	38.1	12.1	15.2	34.3	43.2	12.7	18.7	27.9	36.2
S11-low	13.3	21.0	30.5	38.7	12.7	15.6	34.9	42.9	12.7	19.1	26.7	34.9
S12-high	16.5	20.0	33.0	41.3	8.3	19.4	37.5	43.2	12.7	16.8	33.0	38.1
S12-low	15.2	18.1	32.4	41.3	10.2	19.1	37.5	43.2	15.9	16.5	33.0	38.1
S13	13.7	14.9	25.1	34.6	x	14.0	28.3	38.1	x	x	23.2	32.4
S14	12.7	23.5	x	30.2	x	28.6	x	34.0	x	19.1	x	26.0

Table 4. Sample measurement notes

Sample	Notes
S01	Additional Padded Head Rest. Plastic Molded Seat sewn in.
S02	Removable plastic molding. Removable head pillow. Removable body cushion. Built-in vibration electronics. Removable toy on harness. Solid headrest. Detachable top (all). Depth at hinge = 25.4 cm - Done because it seems deeper than the rest.
S03	Flaps to cover buttons. No plastic molding. No rocking motion. Mesh at head only.
S04	Removable full length cushion. Collapsible. Toy attached to harness. Attachable vibration electronics. Flaps on either end. Mesh only at head. Side flaps. Measurements done without cushion.
S05	Non-Rock Sitting Incline at head = 47.95°, at thigh = 3.2°. Sleeping incline at head = 21.25°, at thigh = 3.65°. All measurements performed with non-rocking stopper down. Removable head pillow. Difficult to assemble (Assembly instructions unclear). Sitting to sleeping incline shift very difficult. Rocker stopper increases incline for both positions. Thin/short mesh around head and torso. Different (cushion) material on side from bight line down. Product depth at head increases, which increases width of mesh. Removable toy mobile. Minimum width measured above top seam before mesh. Plastic molding is (Y) because it is wood/particle board backing (thin, solid), Aluminium frame, and Seat is plastic molding. At hinge, "Solid" measurement is to the Aluminium frame. "Child" (Hinged weight gage infant) shifted in the product when reclined from sitting to sleeping. Repositioned the best we could, hinge line aligned to seat seam (bight line). At 11.4" for sleeping setting, 19.4 cm is to a second material before mesh, and 37.8" is to end of mesh and this second material.
S06	Side mesh only at head. Flaps on either end. Detachable mobile with toy. Attachable vibration electronics. Detachable head pillow. "Mesh" measurements at hinge and knee are actually of second material.
S07	4.4° Lateral tilt towards the Electronic unit. Flat padded head rest. Head of baby (hinged weight gage infant) flush with the product. Plastic molded seat sewn in. Top removable.
S08	Measuring only the sleeper. Detachable head. Non-detachable head pillow. Embedded electronics under foot end. Fairly small product. No mesh. No plastic molding.
S09	Detachable top (all). Removable plastic molding. Solid head rest. Removable toy on harness.
S10	Detachable top (all). Removable plastic molding. Non-detachable head pillow. Detachable body cushion. Attachable electronics on rail.
S11	Dual folding mechanism (legs and top). Removable body cushion. 2 incline settings. Mobile embedded with toy. Fairly wide product (visually). Measurements done without body cushion.
S12	Standing product. Large base. Fairly heavy. 2 incline settings at head. Detachable body cushion. Attachable electronics on rail.
S13	Removable full length cushion. Collapsible. Mesh only up to just above the seat hinge (bight line). Hard plastic molding in two parts; there is a gap between the two parts at the seat bight line.
S14	Measuring only sleeper. Removable full length cushion, collapsible. No mesh. Has insertable thick plastic molding. Measurements from center to "Solid" Refers to measurement made to the edge of the cushion. Plastic molding ends above seat bight line.

The following section from the CPSC study outlines the rationale for product selection for the *in vivo* human biomechanics study. It also includes details related to products which are manufactured by the same company, listed in a blinded fashion as Companies A, B, and C.

3.4 Product Selection Rationale

The project team had to select a portion of these inclined sleep products to include in the biomechanical testing, as time limitations prohibited inclusion of all products. Products were selected firstly if any adverse incidents had been reported to the CPSC. Company A's products represented most of the incidents (83), followed by Company B (7), and Company C (1).

The designs of Company A featured rigid plastic molding that conformed into the sides of the products and fell into two categories: basic (S01 and S09) and deluxe (S02 and S10), which featured a pillow or heavily-padded piece. S01 was selected to represent the basic version of Company A and S02 to represent the deluxe version of Company A because several incidents specifically noted these products.

Company B had products with no plastic molding and had basic (S03 and S04) and deluxe versions with padded pillows (S06) as well as a product that featured a maximum incline outside of the range of 10° to 30° (S05). S03 was chosen to represent the basic version of Company B and S06 to represent the deluxe version because incidents were reported in these products.

Company C had two products which were examined (S08 and S13). The incident occurred in product S08, and it was selected since this was the smallest product with an inclined surface made of a single material with no plastic molding or mesh. S13 was also chosen to be included in the biomechanical study because it had a unique design of plastic molding, with the molding split at the seat bight line.

There was room to include one final product in the biomechanical experiment, and a product that was the most different in design to the others and was manufactured by a different company was sought. This left products S07, S11, S12, and S14. Product S14 was received too late to include in testing. S07 and S12 both featured thick plastic molding, not unlike those from Company A, while product S11 had a unique thin plastic molding. S11 also exhibited near maximum product widths at all of the measurement points, making it different than many other products, so S11 from Company D was chosen as the final product.

The final list of products included in further product analysis and biomechanical testing were: S01, S02, S03, S06, S08, S11, and S13.

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PEER-REVIEWED JOURNAL PUBLICATIONS

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2015

45. **Mannen EM**, Anderson JT, Arnold PM, and Friis EA. "Mechanical Contribution of the Rib Cage in the Human Cadaveric Thoracic Spine," *Spine*. 2015;40(13), pp. E760-766. doi: 10.1097/BRS.0000000000000879. PMID: 25768687
46. **Mannen EM**, Anderson JT, Arnold PM, and Friis EA. "Mechanical Analysis of a Human Cadaveric Thoracic Spine with Intact Rib Cage," *Journal of Biomechanics*. 2015;48(10), pp. 2060-2066. doi: 10.1016/j.jbiomech.2015.03.021. PMID: 25912664.
47. **Mannen EM**, Ranu SS, Villanueva AM‡, Friis EA. "Validation of a Novel Spine Test Machine." *ASME: Journal of Medical Devices*. 2015;9(1):011002-011002-8. Paper No: MED-14-1137; doi: 10.1115/1.4028759.

In review, revision, or preparation

48. Ponte F, Kim HN, Warren A, Iyer S, Han L, **Mannen EM**, Gomez-Acevedo H, Intawat I, Almeida, M, Manolagas S. "Mmp-13 deletion in cells of the mesenchymal lineage increases bone mass, decreases endocortical osteoclast number and attenuates the cortical bone loss caused by estrogen deficiency in mice," *Journal of Bone and Mineral Research.* Submitted April 2021, *in review.*
49. *Katsumi R‡, Bajaj G, Smith JR‡, Mears SC, Stambough JB, **Mannen EM**, Barnes CL. "The influence of knee flexion angle on spinopelvic alignment and global sagittal balance in patients with osteoarthritis." *Journal of Knee Surgery*. Submitted December 2021, *in review.*
50. Wang J‡, Latt LD, Martin RD, **Mannen EM**. "Postural control differences between patients with posterior tibial tendon dysfunction and healthy people during gait," *International Journal of Environmental Research and Public Health*. Submitted November 2021, *in revision.*

BOOK CHAPTERS

1. **Mannen EM**, Anderson DE. "Mechanical testing of the thoracic spine and related implants," in Friis EA(ed). *Mechanical Testing of Orthopaedic Implants.* Cambridge, MA: Woodhead Publishing, an imprint of Elsevier, 2016.
2. Jack MM, Smith KA, Friis EA, **Mannen EM**, Arnold PM. "Anatomic, radiographic, and surgical considerations of global alignment in the thoracolumbar region," in Haid R, Shaffrey CI, Youssef J, Schwab F(eds). *Global Spinal Alignment: principles, pathologies, and procedures*. St. Louis, MO: Quality Medical Publishing, 2015.

INVITED TALKS

2022

1. "Biomechanics of Infants in Common Baby Gear & Orthopaedic Devices: Implications for Musculoskeletal Development," *The 48th Annual David H. Sutherland Pediatric Orthopaedic Visiting Professorship*, University of California – San Diego. May 6, 2022.
2. "Biomechanics Techniques to Help Inform Infant Product Safety," *5th Seattle Children's and Microsoft SIDS Research Summit.* April 2022.

2021

3. "Importance of Biomechanics Research and Its Application to Anatomy," *American Association for Anatomy,* plenary session, virtual due to COVID-19; December 2021.

4. "Exploring Safety of Infant Products through Biomechanics Research," *Laurie's Children's Hospital and Chicago-Area Injury Prevention Group,* Chicago, IL; September 2021.
5. "Exploring Safety of Infant Products through Biomechanics Research," *American Academy of Pediatrics Annual Meeting,* virtual due to COVID-19; October 2021.

2020

6. "Biomechanics in orthopaedics and sports medicine," *The 1st Annual Nicaraguan Sports Medicine Congress*, virtual due to COVID-19; December 2020.
7. "Impact of infant gear on hip position and muscle activity," *The 3rd International NYU Langone Hip Dysplasia Symposium: Collaborating to Solve a Worldwide Problem*, virtual due to COVID-19; September 2020.

2019

8. "Baby Biomechanics: Improving safety and progressing innovation," Inspire ME Seminar Series, Department of Mechanical and Biomedical Engineering, Boise State University, Boise, ID; November 2019.
9. "Biomechanics of Baby Wearing," *The 2nd Annual Hip Dysplasia International Symposium*, New York University School of Medicine, New York, NY; September 2019.
10. "The Utility of Functional Analysis in Patients Afflicted with Spinal Disorders," Invited symposium organized by Dr. Ram Haddas at *North American Spine Society Annual Meeting*, Chicago, IL; September 2019.

2018

11. "How do babies move? Exploring the biomechanical impact of positioning and infant gear," *Department of Mechanical Engineering, Harding University*, Searcy, AR; November 2018.
12. "Women in Mechanical Engineering Networking Event," Panel Member, *Department of Mechanical Engineering, The University of Kansas*, Lawrence, KS; November 2018.
13. "How do babies move? Exploring the biomechanical impact of positioning and infant gear," *Department of Physical Therapy, Washington University in St. Louis School of Medicine*, St. Louis, MO; November 2018.
14. "How do babies move? Exploring the biomechanical impact of positioning and infant gear," *Department of Physiology, University of Southern California*, Los Angeles, CA; September 2018.
15. "Biomechanical Aspects of Babywearing Applied to Infants and Adults: Infant Motion Studies and Muscle Activities during Babywearing," *International Babywearing Conference,* Des Moines, IA; July 2018.

2017

16. "Advancing Thoracic Spine Biomechanics: Improve the Model, Trust the Results," *Department of Biomedical Engineering Lecture Series, University of Arkansas*, Fayetteville, AR; November 2017.
17. "Quantifying Human Motion: Cadaveric and Whole-Body Biomechanics," *Department of Endocrinology, University of Arkansas for Medical Sciences,* Little Rock, AR; September 2017.

2016

18. "Mechanical Testing of the Thoracic Spine and Rib Cage," *University of Arkansas for Medical Sciences,* Little Rock, AR; November 2016.
19. "Orthopaedic Biomechanics using High Speed Stereo Radiography," *Harvard Medical School*, Boston, MA; May 2016.
20. "Mechanical Testing of the Thoracic Spine and Rib Cage," *University of Denver*, Denver, CO; April 2016.

21. "Women in STEM: The good, the bad, and the ugly," *University of Denver's 16th Annual Women's Conference*, Denver, CO; April 2016.

2015

22. "Advancing Thoracic Spine Biomechanics," *The University of Denver*, Denver, CO; July 2015.
23. "Biomechanical Spine Test System," *Applied Test Systems' Sales Meeting*, Butler, PA; June 2015.

2014

24. "Mechanical Contribution of Sequential Ponte Osteotomies in a Cadaveric Thoracic Spine with Intact Ribcage," *Pediatric Spine Case Symposium*, Kansas City, MO; May 2014.
25. "Advancing Thoracic Spine Research", *Mechanical Engineering Graduate Student Seminar Series*, *University of Kansas*, Lawrence, KS; March 2014.

CONFERENCE PROCEEDINGS

*EM Mannen Corresponding Author
‡Mentored Student/Resident/Fellow

2022

1. Hamilton L, Shelburne L, Rullkoetter, PJ, Barnes, CL, **Mannen EM.** "Kinematic Comparison of Medial Pivot Total Knee Arthroplasty and Non-Symptomatic Controls," *ISTA Annual Conference*, 2022; Maui, HI. *In review.*
2. Olvera HL‡, Brittain AR‡, **Mannen EM**, Siddicky SF‡. "Spatiotemporal Biomechanics of Caregivers Carrying Infants in an Outdoor Setting," *University of Maryland McNair Conference,* March 16-20, 2022; College Park, Maryland.
3. *Siegel DS‡, Siddicky SF‡, Prow A‡, Scholes O‡, Davis W‡, **Mannen EM.** "Muscle Utilization of How Babies Achieve a Roll," *9th World Congress of Biomechanics*, July 2022; Taipei, Taiwan. **Podium presentation.**
4. Fitzpatrick C, Farnsworth C, **Mannen EM**, Upasani VV. "2D and 3D Anatomic Characterization of a Porcine Model of Developmental Dysplasia of the Hip," *9th World Congress of Biomechanics,* July 2022; Taipei, Taiwan. **Podium presentation.**
5. *Siddicky SF‡, Eckles JP‡, Wang J‡, Dalal SS‡, Rabenhorst B, Kee J‡, **Mannen EM**, "Ultrasound evaluation of healthy infant hips in the Pavlik harness and commercial baby carriers," *Orthopaedic Research Society Annual Meeting*, Tampa, FL, 2022. **Podium presentation.**
6. *Siddicky SF‡, Huayamave V, **Mannen EM.** "A novel method to quantify continuous kicking force from infants wearing a Pavlik harness," Orthopaedic Research Society Annual Meeting, Tampa, FL, 2022.
7. *Sherrill JT‡, Bumpass DB, **Mannen EM**. "Mechanical Analysis of Three Posterior Cervical Spinal Fusion Assemblies Intended to Cross the Cervicothoracic Junction," *Orthopaedic Research Society Annual Meeting*, 2022; Tampa, FL.

2021

8. *Sherrill JT‡, Bumpass DB, **Mannen EM**. "Mechanical Analysis of Three Posterior Cervical Spinal Fusion Assemblies Intended to Cross the Cervicothoracic Junction," *Cervical Spine Research Society* 2021. **First Place Basic Science Abstract**.
9. *Siegel DN‡, Davis WD‡, Prow A‡, Scholes O‡, Siddicky S, **Mannen EM**, ‡. "The Unexplored Milestone: Kinematics and Muscle Utilization of How Babies Roll," Mountain West Biomechanics Society Annual Meeting, 2021; virtual due to COVID-19.

10. *Goldrod S‡, Siddicky SF‡, **Mannen EM**. "Hip Angles of an Infant in Different Baby Carrier Styles," *Undergraduate Research Symposium*, Boise State University, 2021; virtual due to COVID-19. **Student Poster Award.**
11. *Siddicky SF‡, Wang J‡, Rabenhorst BR, **Mannen EM**. "Lower extremity biomechanics of healthy infants, infants with hip instability, and infants treated for developmental dysplasia of the hip with the Pavlik harness." Canadian Society for Biomechanics CSB-SCB Annual Conference, 2021; virtual due to COVID-19.
12. *Siegel DN‡, Davis WD‡, Prow A‡, Scholes O‡, Siddicky S, **Mannen EM**, ‡. "The Unexplored Milestone: Kinematics and Muscle Utilization of How Babies Roll," Graduate Student Showcase, Boise State University, 2021; virtual due to COVID-19.
College of Engineering First Place Award Winner.
13. *Sherrill JT‡, Bumpass DB, **Mannen EM**. "Mechanical analysis of posterior spinal fusion assemblies intended to cross the cervicothoracic junction." Translational Science, 2021; virtual due to COVID-19. **Podium Presentation.**
14. ***Mannen EM**, Wang J‡, Siddicky SF‡, Carroll JL, Rabenhorst BM, Bumpass DB, Whitaker BN. "Is This Safe for Baby? Using Biomechanics to Explore Safety of Inclined Sleepers." American Society of Biomechanics Annual Meeting, 2021; virtual due to COVID-19. **Podium Presentation. Abstract part of the ASB Early Career Achievement Award.**
15. *Siegel DN‡, Davis WD‡, Prow A‡, Scholes O‡, **Mannen EM**, Siddicky SF‡. "The Unexplored Milestone: Kinematics and Muscle Utilization of How Babies Roll," American Society of Biomechanics Annual Meeting, 2021; virtual due to COVID-19. **Podium Presentation.**
16. *Hamilton LD, Shelburne KB, Rullkoetter PJ, Barnes CL, **Mannen EM**. "Kinematic performance of medial pivot total knee arthroplasty." Orthopaedic Research Society Annual Meeting, 2021; virtual due to COVID-19.
17. Lim L, Huayamave V, Walck C, **Mannen EM**, Siddicky SF‡. "Estimating infant hip joint moments using a novel musculoskeletal model." Orthopaedic Research Society Annual Meeting, 2021; virtual due to COVID-19. **Podium Presentation**.

2020

18. *Wang J‡, Siddicky SF‡, Johnson T, Kapil N, Majmudar B, **Mannen EM**. "Supine lying center of pressure characteristics as a predictor of developmental stages in early infancy." American Academy of Pediatrics Annual Meeting, 2020; virtual due to COVID-19.
19. Mayes W‡, **Mannen EM**, Barnes CL, Edwards PK, Mears, Severin AC, Stambough JB. "Functional Outcomes of Modular Knee Fusion for Extensor Disruption and Prosthetic Joint Infection" 30th AAHKS Annual Meeting, 2020; Dallas, Texas.
20. *Katsumi R‡, Stambough J, Mears SC, Edwards P, Barnes CL, **Mannen EM.** "The influence of knee flexion angle on sagittal spinopelvic alignment and sagittal balance in patients with knee osteoarthritis," The 12th Annual Meeting of Japanese Orthopaedic Society of Knee, Arthroscopy, and Sports Medicine / The 46th Annual Meeting of the Japanese Orthopaedic Society for Sports Medicine, 2020; Kobe, Hyogo, Japan.
21. *Wang J‡, Siddicky SF‡, Carroll JL, Rabenhorst BM, Bumpass DB, Whitaker BN, **Mannen EM**, "Do inclined sleeping surfaces impact infants' upper body muscle activity and movement?", American Society of Biomechanics Annual Conference, 2020; Atlanta, GA *(virtual due to COVID-19).*
22. *Siddicky SF‡, Wang J‡, Hefley III W‡, Rabenhorst B, Aronson EA, **Mannen EM**, "Does the Pavlik harness treatment cause lower extremity biomechanical changes in infants?," American Society of Biomechanics Annual Conference, 2020; Atlanta, GA *(virtual due to COVID-19).*
23. Lim Y, Huayamave V, Walck C, **Mannen EM**, Siddicky S. "Motion-based scaling of infant musculoskeletal model for DDH treatment." 26th Congress of the European Society of Biomechanics, 2020; Milan, Italy, *in review.*

24. Kapil N, Escapita A, Simpson H, Siddicky SF‡, Wang J‡, **Mannen EM**, Johnson T. "Artificial Intelligence-Based Quantification of the General Movement Assessment Using Center of Pressure Patterns in Healthy Infants." Translational Science, 2020; Washington, DC.
25. *Siddicky SF‡, Rabenhorst BM, Aronson E, Wang J‡, **Mannen EM**. "Lower extremity muscle activity and hip range of motion of infants with hip dysplasia: how does it compare to healthy infants?" Pediatric Orthopaedic Society of North America Annual Meeting, 2020; San Diego, CA, *in review*.
26. *Siddicky SF‡, Rabenhorst BM, Wang J‡, Aronson E, McCoy A‡, Casper E‡, Mohler S‡, **Mannen EM**. "Biomechanical Changes Following Pavlik Harness Treatment For Developmental Dysplasia Of The Hip," Orthopaedic Research Society Annual Meeting, 2020; Phoenix, AZ.
27. *Severin AC‡, Mayes W‡, Mears SC, Stambough JB, Edwards PK, Gaffney BMM, Barnes CL, **Mannen EM**. "Functional, Spatiotemporal, And Kinematic Outcomes Of Subjects With Modular Knee Arthrodesis," Orthopaedic Research Society Annual Meeting, 2020; Phoenix, AZ.
28. *Severin AC‡, Mayes W‡, Mears SC, Stambough JB, Edwards PK, Barnes CL, **Mannen EM**. "Clinical Outcomes And Postural Sway In Patients With Unilateral Modular Knee Arthrodesis," Orthopaedic Research Society Annual Meeting, 2020; Phoenix, AZ.
29. *Katsumi R‡, Mears SC, Stambough JB, Edwards PK, Barnes CL, **Mannen EM**. "Relationship Of Knee Flexion Angle And Sagittal Spinopelvic Alignment In Patients With Knee Osteoarthritis," Orthopaedic Research Society Annual Meeting, 2020; Phoenix, AZ.
30. *Hockett S‡, Self M‡, Sherrill JS‡, Mears SC, Barnes CL, **Mannen EM**. "Mechanical Testing Of Synthetic Bone-graft For Core Decompression Treatment Of Femoral Head Avascular Necrosis," Orthopaedic Research Society Annual Meeting, 2020; Phoenix, AZ. **Oral presentation** given by S Hockett.
31. *Mayes W‡, Severin AC‡, Stambough JB, Edwards PK, Barnes CL, **Mannen EM**, Mears SC. "Management of Periprosthetic Joint Infection and Extensor Mechanism Disruption with Modular Knee Fusion: Clinical and Biomechanical Outcomes," *American Academy of Orthopaedic Surgeons Annual Meeting*, 2020; Orlando, FL. **Oral presentation** given by W Mayes..
32. *Katsumi R‡, Stambough JB, Mears SC, Edwards PK, Barnes CL, **Mannen EM**. "The influence of knee flexion angle on sagittal spinopelvic alignment in patients with knee osteoarthritis," *American Academy of Orthopaedic Surgeons Annual Meeting*, 2020; Orlando, FL.

2019

33. *Wang J‡, Siddicky SF‡, Johnson T, Kapil N, Majmudar B, **Mannen EM**. "Supine lying center of pressure characteristics as a predictor of developmental stages in early infancy," *2019 NIH IDeA Southeast Regional Conference*, 2019; Louisville, KY.
34. *Siddicky SF‡, Rabenhorst B, Wang J‡, Aronson E, McCoy A‡, Casper E‡, Mohler S‡, **Mannen EM**. "The biomechanics of infants treated for developmental dysplasia of the hip with the Pavlik harness," *2019 NIH IDeA Southeast Regional Conference*, 2019; Louisville, KY.
35. Huayamave V, **Mannen EM**, Stanton N, Walck C, Siddicky SF, Price C, "A novel computational model of babywearing to predict growth and development of the pediatric hip joint," *VII International Conference on Coupled Problems in Science and Engineering*, 2019; Sitges, Spain.
36. *Barnes CL, Severin AC‡, Mears SC, Edwards PK, Stambough JB, **Mannen EM**. "Technique variability in performing the anterior drawer test for flexion instability after TKA," *The Knee Society Annual Meeting*, 2019; Cape Neddick, ME.
37. *Barnes CL, Severin AC‡, Tackett SA, **Mannen EM**. "Kinematic and kinetic demands on the lead and trail legs during a golf swing," *Hip Society Annual Meeting,* 2019; Kohler, WI. **Oral presentation** given by CL Barnes.
38. Alghazali K, Srivatsan M, Trigwell S, Bumpass DB, **Mannen EM**, McCarthy RE, Anderson DE, Biris AS, Ballard S. "NuCress scaffold as a spine fusion novel solution," *Defense Techconnect Fall Summit and Expo*, 2019; National Harbor, MD.

39. Kapil N, Escapita A, Simpson H, Siddicky SF‡, Wang J‡, **Mannen EM**, Johnson T. "Quantification of the General Movement Assessment Using Center of Pressure Patterns in Healthy Infants," *Biomedical Engineering Society Annual Meeting*, 2019; Philadelphia, PA.
40. Melendez-Suchi C, Harb AM, Li-Han, Warren A, **Mannen EM**, Almeida M, Iyer S. "Deletion of the ER stress sensor Ira1a, but not Perk, in the osteoblast lineage decreases bone mass," *American Society for Bone and Mineral Research Annual Meeting*, 2019; Orlando, FL. **Oral presentation** given by S Iyer.
41. Li X, Li H, Nookaew I, **Mannen EM**, Silva MJ, Almeida M, Xiong J. "Stimulation of piezo1 by mechanical loading promotes bone anabolism," *American Society for Bone and Mineral Research Annual Meeting*, 2019; Orlando, FL. **ASBMR Most Outstanding Basic Abstract Award.**
42. Kapil N , Escapita A, Simpson H, Siddicky SF‡, Wang J‡, **Mannen EM**, Johnson T. "Quantification of the General Movement Assessment using center of pressure patterns in healthy infants," *The 47th Annual Child Neurology Society Meeting*, 2019; Charlotte, NC.
43. *Smithson K‡, Smith JR‡, Davis W‡, Dean W‡, Hogue W, Ahmadi S, **Mannen EM**. "Biomechanics of Axial Load Transmission across the Native Human Elbow," *74th Annual Meeting of the American Society for Surgery of the Hand*, 2019; Las Vegas, NV.
44. *Siddicky SF‡, Wang J‡, Rabenhorst BM, McCarthy RE, Tackett SA, Bumpass DB, **Mannen EM**. "Daily infant positioning and its implications on long-term spine and lower extremity health," *South Central American Society of Biomechanics Annual Meeting*, 2019; Dallas, TX. **Oral presentation** given by SF Siddicky.
45. *Severin AC‡, Tackett SA, Mayes W‡, Mears SC, **Mannen EM**. "Spatiotemporal gait parameters following unilateral knee arthrodesis surgery: a case study." *South Central American Society of Biomechanics Annual Meeting*, 2019; Dallas, TX. **Oral presentation** given by EM Mannen.
46. *Wang J‡, Siddicky SF‡, Johnson T, Kapil N, Tackett SA, **Mannen EM**. "Supine lying center of pressure as a predictor of developmental disorders in early infancy," *South Central American Society of Biomechanics Annual Meeting*, 2019; Dallas, TX. **Oral presentation** given by J Wang.
47. *Severin AC‡, Tackett SA, Simpson HE‡, Barnes CL, **Mannen EM**. "Is hand speed an adequate predictor of club head speed or ball speed during a golf swing?" *International Society of Biomechanics in Sport Annual Conference*, 2019; Oxford, OH. **Oral presentation** given by AC Severin. **Nominated for ISBS New Investigator Award.**
48. *Sherrill JT‡, Siddicky SF‡, Davis W‡, Chen C‡, **Mannen EM**. "Validation of a spine biomechanics simulator," *XXVII Congress of the International Society of Biomechanics & 43rd Annual Meeting of the American Society of Biomechanics,* 2019; Calgary, Canada.
49. *Siddicky SF‡, Wang J‡, Bumpass DB, McCarthy RE, Tackett SA, **Mannen EM**. "The importance of prone time in the healthy musculoskeletal development of infants," *XXVII Congress of the International Society of Biomechanics & 43rd Annual Meeting of the American Society of Biomechanics,* 2019; Calgary, Canada.
50. *Severin AC‡, Tackett SA, Barnes CL, **Mannen EM**. "Lower body joint moments in older adults with osteoarthritis of the trailing knee during golf swings," *XXVII Congress of the International Society of Biomechanics & 43rd Annual Meeting of the American Society of Biomechanics*, 2019; Calgary, Canada.
51. *Severin AC‡, Tackett SA, Barnes CL, **Mannen EM**. "Transverse plane golf swing kinematics and performance in older adults with osteoarthritis of the trailing knee," *XXVII Congress of the International Society of Biomechanics & 43rd Annual Meeting of the American Society of Biomechanics*, 2019; Calgary, Canada.
52. *Smithson K‡, Smith JR‡, Davis W‡, Dean W‡, Hogue W, Ahmadi S, **Mannen EM**. "Biomechanics of Axial Load Transmission across the Native Human Elbow," *Southern Orthopaedic Association Annual Meeting*, 2019; Amelia Island, FL. **Oral presentation** given by K Smithson.
53. *Siddicky SF‡, Tackett SA, Buchele L‡, Rabenhorst BR, **Mannen EM**. "Infant hip position and lower extremity muscle activity in an inward facing baby carrier and the Pavlik harness," *Gait and*

Clinical Movement Analysis Society Annual Meeting, 2019; Dallas, TX. **Oral presentation** given by SF Siddicky.

54. Stanton N, Siddicky SF‡, Price C, **Mannen EM**, Huayamave V. "Biomechanics of babywearing: Implications for hip joint development." *29th International Pediatric Association Congress*, 2019; Panama City, Panama. **Oral presentation** given by V Huayamave.
55. ***Mannen EM**, Rabenhorst B, Krishnan A‡, Tackett SA, McCarthy R, Bumpass DB. "Keep on carrying on: Effects of carrying on infant nutrition, motor development, and social interaction. Infant Positioning Impacts Muscle Activity: Implications for Proper Musculoskeletal and Motor Development." Paper Symposium with A Bigelow, E Little, L Williams. *Society for Research on Child Development Bi-Annual Conference*, 2019; Baltimore, MD. **Oral presentation** given by **EM Mannen**.
56. *Severin AC‡, Tackett SA, Barnes CL, **Mannen EM**. "Transverse plane biomechanics in older adults with osteoarthritis of the trailing knee," *Mid-South Movement Science Conference*, 2019; Memphis, TN. **Oral presentation** given by AC Severin.
57. Severin AC‡, Tackett SA, **Mannen EM**. "Altered kicking kinematics in female collegiate soccer players with previous ACL reconstruction," *Mid-South Movement Science Conference*, 2019; Memphis, TN. **Oral presentation** given by AC Severin.
58. *Sherrill JT‡, Siddicky SF‡, Davis W‡, Dalal S‡, **Mannen EM**. "Validation of a spine biomechanics simulator," *Mid-South Movement Science Conference*, 2019; Memphis, TN. **Oral presentation** given by JT Sherrill.
59. *Smith JR‡, Smithson K‡, Davis W‡, Dean W‡, Hogue W, Ahmadi S, **Mannen EM**, "Load Distribution across the Native Human Elbow," *Mid-South Movement Science Conference*, 2019; Memphis, TN.
60. *Siddicky SF‡, Wang J‡, Bumpass DB, McCarthy RE, Tackett SA, **Mannen EM**. "Infant muscle activity during tummy time: Implications for musculoskeletal development," Mid-South Biomechanics Conference, 2019; Memphis, TN. **Oral presentation** given by SF Siddicky.
61. *Siddicky SF‡, Rabenhorst BM, Tackett SA, Buchele L‡, **Mannen EM**, "Lower extremity hip position and muscle activity during babywearing in soft structured baby carriers: Implications for developmental dysplasia of the hip," *Orthopaedic Research Society Annual Meeting*, *Late Breaking Abstract,* 2019; Austin, TX.
62. *Gean RP‡, Martin RD, Severin AC‡, Queen RM, Barnes SG‡, Butler R, Barnes CL, **Mannen EM**. "The effect of a corrective heel lift on lower body symmetry during gait with an orthopaedic walking boot." *Orthopaedic Research Society Annual Conference*, 2019; Austin, TX. **Oral presentation** during Foot and Ankle Research Interest Group given by AC Severin.
63. *Severin AC‡, Mears SC, Tackett SA, Barnes CL, **Mannen EM**. "Rotational kinematics during a golf swing in older adults with and without osteoarthritis of the knee." *Orthopaedic Research Society Annual Conference*, 2019; Austin, TX.

2018

64. *Sherrill J‡, **Mannen EM**. "Validation of a spine biomechanics simulator," *UAMS Graduate Student Research Summit*, 2018; Little Rock, AR.
65. *Sherrill J‡, **Mannen EM**. "Validation of a spine biomechanics simulator," *Arkansas Chapter of the Society for Neuroscience Annual Meeting*, 2018; Little Rock, AR.
66. *Sherrill JT‡, **Mannen EM**. "Validation of a Spine Biomechanics Simulator." *UAMS Graduate Student Association Research Symposium*, 2018; Little Rock, AR.
67. Mears SC, Wilson M‡, **Mannen EM**, Tackett SA, Barnes CL. "Position of the hip in yoga." *34th Annual Arkansas Orthopaedic Forum*, 2018; Little Rock, AR. **Oral presentation** given by M Wilson. *James Aronson, M.D., Resident Research Competition Winner*.

68. ***Mannen EM**, Krishnan A‡, Sachleben BC. "Lower extremity muscle activity of healthy infants: Implications for hip dysplasia patients." *American Society of Biomechanics Annual Conference*, 2018; Rochester, MN. **Oral presentation** given by EM Mannen.
69. *Havens KL, Kahney A‡, **Mannen EM**. "Asymmetrical stance during child carrying: Implications for back pain." *American Society of Biomechanics Annual Conference*, 2018; Rochester, MN. **Oral presentation** given by KL Havens.
70. Smeltzer MS, Biris AS, Anderson DE, Meeker DG, Beenken KE, Alghazali KM, Barnes B, Bourdo S, Berryhill S, **Mannen EM**, Cherney S. "Use of a novel 3D scaffold technology as a tissue regeneration device for co-therapy in simultaneous prevention of osteomyelitis and promotion of bone regeneration across a segmental bone defect following traumatic injury." *Military Health System Research Symposium*, 2018.
71. ***Mannen EM**, Krishnan AR‡, Tackett SA, McCarthy RE, Bumpass, DB. "Infant positioning impacts neck and back muscle activity: a pilot study exploring implications for spinal development." *North American Spine Society Annual Conference*, 2018; Los Angeles, CA. **Oral presentation** given by EM Mannen.
72. Bumpass BD, **Mannen EM**, Cryar K‡, McCarthy RE. "Implant retrieval analysis for growth guidance constructs: a mechanical analysis." *North American Spine Society Annual Conference,* 2018; Los Angeles, CA. **Oral presentation** given by DB Bumpass.
73. ***Mannen EM**, Kahney A‡, Havens KL. "Babywearing offers caregivers biomechanical benefits during prolonged standing." *Mid-South Biomechanics Conference*, 2018; Memphis, TN. **Oral presentation** given by EM Mannen.
74. **Mannen EM**, Friis EA, Sis HL, Wong BM, Cadel ES, Anderson DE. "The rib cage stabilizes the cadaver spine with follower load under dynamic moments." *Mid-South Biomechanics Conference*, 2018; Memphis, TN. **Oral presentation** given my EM Mannen.
75. **Mannen EM**, Kefala VK, Rullkoetter PJ, Shelburne KB. "Natural knee tibiofemoral and patellofemoral kinematics during comprehensive activities of daily living." *World Congress of Biomechanics*, 2018; Dublin, Ireland. **Oral presentation** given by KB Shelburne.
76. Ali AA, **Mannen EM**, Liu X, Schmidt W, Rullkoetter PJ, Shelburne KB. "An experimental and computational modeling framework for evaluation of in-vivo knee mechanics." *Orthopaedic Research Society,* 2018; New Orleans, LA. **Oral presentation** given by AA Ali.
77. Mears SC, Tackett SA, Wilson M‡, **Mannen EM**, Barnes CL. "Yoga and hip range of motion." *Mid-America Orthopaedic Association*, 2018; San Antonio, TX.

2017

78. ***Mannen EM**, Kahney A‡. "Impact of baby carrying method on postural sway in prolonged standing." *American Society of Biomechanics*, 2017; Boulder, CO.
79. Viggiani D, **Mannen EM**, Nelson-Wong E, Wong A, Ghiselli G, Shelburne KB, Callaghan JP, Davison BS. "Time-varying contributions to lumbar lordosis during an unstable sitting task in people who do and do not develop low back pain during standing." *American Society of Biomechanics*, 2017; Boulder, CO.
80. Anderson DE, **Mannen EM**, Tromp R, Wong BM, Sis HL, Cadel ES, Friis EA, Bouxsein ML. "Intervertebral disc pressure variation in cadaveric thoracic spines under applied dynamic moments." *American Society of Biomechanics*, 2017; Boulder, CO.
81. *Kahney A‡, **Mannen EM**. "Baby carrying method impacts upper extremity muscle activity in prolonged standing." *Rocky Mountain American Society of Biomechanics*, 2017; Estes Park, CO.
82. *Bachman EC‡, Otmane A‡, Davidson BS, Shelburne KS, Currie SJ, McPoil TG, **Mannen EM**. "Foot posture in normal and pronated feet during gait." *Rocky Mountain American Society of Biomechanics*, 2017; Estes Park, CO. **Oral presentation** given by EC Bachman. **Award for Best Undergraduate Podium Presentation**.

83. Anderson DE, **Mannen EM**, Tromp R, Wong BM, Sis HL, Cadel ES, Friis EA, Bouxsein ML. "The rib cage affects intervertebral disc pressures in dynamic tests of cadaveric thoracic spines." *2nd International Workshop on Spine Loading and Deformation,* 2017; Berlin, Germany. **Oral presentation** given by DE Anderson.
84. **Mannen EM**, Kefala V, Ali AA, Walter JP, Reilly KR, Jackels MK, Liu X, Schmidt W, Rullkoetter PJ, Shelburne KB. "Tibiofemoral Kinematics of Healthy Older Adults during Dynamic Seiza-Style Kneeling: A Pilot Study," *Orthopaedic Research Society: Late-Breaking Abstract*, 2017; San Diego, CA.
85. *Bachman EC‡, Otmane A‡, Davidson BS, Shelburne KS, Currie SJ, McPoil TG, **Mannen EM**. "Foot posture and mobility in normal and pronated feet during gait using high-speed stereo radiography." *American College of Sports Medicine*, 2017; Denver, CO.
86. **Mannen EM**, Ali AA, Walden S, Dennis DA, Haas B, Rullkoetter PJ, Shelburne KB. "Influence of implant design on knee mechanics in posterior-stabilized rotating platform TKA." *Orthopaedic Research Society*, 2017; San Diego, CA.
87. *Bachman EC‡, Otmane A‡, Davidson BS, Shelburne KS, Currie SJ, McPoil TG, **Mannen EM**. "Effectiveness of foot orthoses in controlling the posture of medial longitudinal arch: a pilot study." *Orthopaedic Research Society*, 2017; San Diego, CA.
88. Kefala VK, Ali AA, **Mannen EM**, Kim RH, Rullkoetter PJ, Shelburne KB. "Assessment of patellar kinematics in healthy older adults." *Orthopaedic Research Society*, 2017; San Diego, CA. **Oral presentation** given by VK Kefala.
89. **Mannen EM**, Anderson JT, Arnold PA, Friis EA. "Biomechanical cadaveric study to determine change in range-of-motion of human thoracic spine and rib cage due to sequential Ponte osteotomies," *American Association of Neurological Surgeons/Congress of Neurological Surgeons Joint Section of Disorders of the Spine and Peripheral Nerves Summit*, 2017; Las Vegas, NV.

2016

90. Kefala VK, Ali A, **Mannen EM**, Shelburne K. "Natural tibiofemoral and patellofemoral kinematics of the knee in older adults during activities of daily living," *International Society for Technology in Arthroplasty*, 2016; Boston, MA**. Oral presentation** given by EM Mannen.
91. Ali A, **Mannen EM**, Smoger L, Haas B, Laz P, Rullkoetter PJ, Shelburne KB. "Evaluation of in-vivo mechanics for medialized dome and medialized anatomic patellofemoral geometries during knee extension and lunge," *International Society for Technology in Arthroplasty*, 2016; Boston, MA. **Oral presentation** given by PJ Rullkoetter.
92. **Mannen EM**, Friis EA, Sis HL, Wong BM, Cadel ES, Anderson DE. "Biomechanical impact of the rib cage in a thoracic cadaveric spine with a compressive follower load," *American Society of Biomechanics*, 2016; Raleigh, NC.
93. **Mannen EM**, Arnold PA, Anderson JT, Friis EA. "Sequential Ponte osteotomies increase sagittal plane flexibility in a thoracic cadaveric model with rib cage," *American Society of Biomechanics*, 2016; Raleigh, NC.
94. Kefala VK, Ali A, **Mannen EM**, Davidson BS, Shelburne K. "Tibiofemoral and patellofemoral kinematics of healthy subjects in a seated knee extension and lunge using high-speed stereo radiography," *American Society of Biomechanics*, 2016; Raleigh, NC.
95. **Mannen EM**, Friis EA, Sis HL, Wong BM, Cadel ES, Anderson DE. "Human cadaveric thoracic spine range-of-motion with a compressive follower load increases with rib cage removal," *North American Spine Society*, 2016; Boston, MA.
96. Galvis SN, Arnold JA, **Mannen EM**, Wong BM, Sis HL, Cadel ES, Anderson DE, Arnold PA, Friis EA. "Biomechanical assessment of a growth friendly rod construct," *Scoliosis Research Society*, 2016.
97. Galvis SN, Arnold JA, **Mannen EM**, Wong BM, Sis HL, Cadel ES, Anderson DE, Arnold PA, Friis EA. "Intradiscal pressure changes in a growing rod cadaver model," *Lumbar Spine Research Society*, 2016.

98. Sis HL, **Mannen EM**, Wong BM, Cadel ES, Bouxsein ML, Anderson DE, Friis EA. "Effect of a follower load on the motion and stiffness of a human cadaveric thoracic spine with an intact rib cage," *Orthopaedic Research Society*, 2016.
99. Galvis SN, Arnold JA, **Mannen EM**, Wong BM, Sis HL, Cadel ES, Anderson DE, Arnold PA, Friis EA. "Intradiscal pressure changes in a growing rod cadaver model," *Orthopaedic Research Society*, 2016.

2010 – 2015

100. Anderson DE, **Mannen EM**, Sis HL, Wong BM, Cadel ES, Friis EA, Bouxsein ML. "Effects of a follower load and rib cage on intervertebral disc pressure and sagittal plane curvature in static tests of cadaveric thoracic spines," *American Society of Biomechanics Meeting*, 2015.
101. **Mannen EM**, Arnold PA, Anderson JT, Friis EA. "Range-of-motion analysis of sequential Ponte osteotomies in a continuously loaded full thoracic spine cadaveric model with attached ribcage," *Lumbar Spine Research Society*, 2014**. Oral presentation** given by PA Arnold.
102. **Mannen EM**, Arnold PA, Anderson JT, Friis EA. "Range-of-motion analysis of sequential Ponte osteotomies in a continuously loaded full thoracic spine cadaveric model with attached ribcage," *American Academy of Neurological Surgery,* 2013.
103. **Mannen EM**, Arnold PA, Anderson JT, Friis EA. "Range-of-motion analysis of sequential Ponte osteotomies in a continuously loaded full thoracic spine cadaveric model with attached ribcage," *Orthopaedic Research Society,* 2013.
104. **Lewis EM**, Friis EA, Blair E. "Bioengineering toolkits for 4th and 5th grade teachers," *STEM Think Tank Conference*, 2012.
105. **Lewis EM**, Friis EA, Blair E. "Bioengineering toolkits for 4th and 5th grade teachers," *Capitol Research Summit*, 2010.
106. **Lewis EM**, Friis EA, Blair E. "NSF RET program to incorporate bioengineering education in the 4th and 5th grades," *Society for Biomaterials Annual Meeting,* 2010.

RESEARCH SUPPORT

Ongoing

Boise State University

2021 "The Effect of Infant Carrier On Pressure Distribution In The Wearer And Infant," *Labtest International, Inc*. PI: **EM Mannen**. 3/1/2021 to 4/1/2021.

2020 – 2024 "Infant Biomechanics and Suffocation Research," *U.S. Consumer Product Safety Commission.* PI: **EM Mannen,** Co-I: J Carroll.
Task Order 0002: 09/28/2021 to 09/27/2024.
Task Order 0003: 09/28/2021 to 09/27/2022.

2020 – 2021 "Biomechanics of Infant Rolling," PI: **EM Mannen.** 07/07/2020 to 12/31/2021**.**

Pending

Boise State University

2022 "Role of Acetabulum Mechanical Environment on Developmental Dysplasia of the Hip," ~$2,500,000. *NICHD R01.* PI: **Erin Mannen**; Co-PIs: G Uzer, T Lujan, C Fitzpatrick. Applied 2/7/2022.

"Development and validation of a smart harness to study babies with developmental

dysplasia of the hip," $125,000 (annually), *NIH COBRE - Convergent Engineering and Biomolecular Science.* PI: J Browning; Role: Research Project Leader. Anticipated 1/1/2023 to 1/1/2026. Applied 1/27/2022.

Completed

Boise State University

2020 – 2021 "Infant Biomechanics and Suffocation Research," *U.S. Consumer Product Safety Commission.* PI: **EM Mannen,** Co-I: J Carroll.
Task Order 0001: 09/24/2020 to 09/23/2021.

UAMS

2019 – 2021 "An ultrasonographic approach to assessing hip alignment and the efficacy of the abduction brace compared to common infant devices," $17,650 (all direct), *International Hip Dysplasia Institute*, (February 2019 to February 2021). Co-PIs: **EM Mannen**, BR Rabenhorst.

2019 – 2021 "In vivo evaluation of medial-pivot cruciate-sacrificing TKA kinematics, loading, and mechanics," $139,324 ($101,129 direct), *Medtronic, Inc.*, Co-PIs: **EM Mannen**, CL Barnes; Sub-Is: KB Shelburne, PJ Rullkoetter

2020 – 2021 "Biomechanical implications of long cervical fusions: where should they end?," $25,000 (all direct), UAMS Barton Intramural Pilot Funding, Co-PIs: **EM Mannen** and DB Bumpass.

2019 – 2022 "A Multi-Scale Biomechanical Model of the Infant Hip to Progress Innovation in Pediatric Hip Dysplasia Rehabilitation," $200,000/year (all direct). *UAMS Center for Musculoskeletal Disease Research Pilot Project*, NIH 1P20GM125503. PI: C O'Brien Project PI: **EM Mannen**, Co-Is: V Huayumave, BM Rabenhorst.

2019 – 2020 "Implementation and Quantification of the General Movement Assessment for Early Detection of Cerebral Palsy in Infants," $50,000 (all direct), KL2 Pilot Award, PI: TL Johnson, Co-Is: **EM Mannen**, B Majmudar, S Cobb.

2019 – 2020 "Biomechanical quantification of flexion instability for total knee arthroplasty," $65,000 (all direct), *UAMS Center for Musculoskeletal Disease Research Pilot Project*, NIH 1P20GM125503. PI: C O'Brien; Pilot PI: SC Mears; Pilot Sub-I: **EM Mannen**.

2017 – 2020 "Impact of Position on Infant Biomechanics," $39,961 ($31,724 direct), *Boba, Inc.*, PI: **EM Mannen**.

2018 – 2019 "Biomechanical Analysis of Inclined Sleeper Infant Products," $248,432 ($197,787 direct), *United States Consumer Product Safety Commission*, Solicitation Number 61320618Q0200, sole source contract. PI: **EM Mannen**, Sub-Is: B Rabenhorst, DB Bumpass, J Carroll, B Whitaker.

2018 – 2019 "Biomechanics of healthy infants and mildly dysplastic infants," $75,000 (all direct), *UAMS Center for Musculoskeletal Disease Research Start-up Funds*, NIH 1P20GM125503; PI: C O'Brien; Awardee: **EM Mannen**, UAMS.

2018 – 2019 "Biomechanics of non-surgically treated infants with developmental hip dysplasia," $65,000 (all direct), *UAMS Center for Musculoskeletal Disease Research Pilot Project*, NIH 1P20GM125503; PI: C O'Brien; Pilot Awardee: **EM Mannen**, UAMS

2018 "Evaluation of physiologic loading of the ulnohumeral and radiocapitellar joints following radial head arthroplasty," $16,233 (sub-award $6,990), *Acumed, LLC.* PI: S Ahmadi; Sub-I: **EM Mannen**, UAMS.

2017 – 2018 "Infant Lower-Limb Muscle Activity during Babywearing," $10,187 (all direct), *International Hip Dysplasia Institute*, PI: **EM Mannen**, UAMS.

University of Denver

2016 – 2017 "Biomechanics of the Babywearing Mother," $20,000, *Ergobaby, Inc*. (July 2016 to June 2017) PI: EM Mannen; University of Denver.

2016 – 2018 "Comparison of the Conformis iTotal CR and Competitive Devices using Functional Activity Measurement and Analyses," $60,600, *ConforMIS*, PI: PJ Rullkoetter, Sub-Is: KB Shelburne, **EM Mannen**, CM Myers; University of Denver.

2015 "Biomechanical Changes in the Thoracic Spine with a Follower Load," $40,000, *National Institute on Aging NIH Subcontract (K99AG042458)*. PI: DE Anderson; Subaward PI: EA Friis, Subaward Co-I: **EM Mannen**; University of Kansas.

University of Kansas

2010 – 2014 Madison and Lila Self Graduate Fellowship, $164,000, University of Kansas.

2009 – 2010 Institute for Advancing Medical Innovation Fellowship, $40,000; University of Kansas.

2007 – 2008 "Quantifying the envelope of motion of the porcine knee," $2,300, Undergraduate Research Award; University of Kansas.

2007 Pratt Engineering Research Fellow: NSF Research Experience for Undergraduates, $3,750; Duke University.

Awarded, Declined to Accept Funding

2018 "Hip positioning and muscle activity of infants with hip instability," $50,000 (all direct), *UAMS College of Medicine Research Scholar Pilot Grant Award in Child Health*, PI: **EM Mannen**, Co-Is: RD Blasier, B Rabenhorst, B Sachleben, UAMS.

TEACHING EXPERIENCE

Boise State University, Boise, ID, USA

2022 Spring **ME 356: Introduction to Solid Biomechanics**
29 students, flipped-classroom style.

2021 Fall **ENGR 210 / ME 201: Engineering Mechanics I**
76 students, specifications-grading, flipped-classroom style.

Guest Lectures

1. "Infant Biomechanics," Interdisciplinary PhD Program. *University of Texas, El Paso.* Instructor: Dr. Jeffrey Eggleston, virtual. November 2021.

2021 Spring **ME 356: Introduction to Solid Biomechanics**
30 students, hybrid / flipped classroom style amid COVID-19 pandemic. **4.5/5.0**

Guest Lectures

1. "Infant Biomechanics," MBE 112: Intro to Biomedical Engineering, Mechanical & Biomedical Engineering Department, *Boise State University.* Instructor: Dr. Trevor Lujan, virtual. February 2021.

2020 Fall **ENGR 210 / ME 201: Engineering Mechanics I**
45 students, hybrid / flipped classroom style amid COVID-19 pandemic. **4.8/5.0**

ME 356: Introduction to Solid Biomechanics
5 students, hybrid / flipped classroom style amid COVID-19 pandemic. **4.8/5.0**

Guest Lectures

1. "Infant Biomechanics," Interdisciplinary PhD Program. *University of Texas, El Paso.* Instructor: Dr. Jeffrey Eggleston, virtual. November 2020.
2. "My academic journey," Graduate Biomechanics, *Auburn University*, Auburn, GA, USA. Instructor: Dr. Jaimie Roper, October 2020.

University of Arkansas for Medical Sciences, Little Rock, AR, USA
2017 – 2020 **Orthopaedic Surgery Resident Lecture Series,** Orthopaedic Surgery

University of Kansas, Lawrence, KS, USA
2013 **Instructor,** Mechanical Engineering
ME 208: Introduction to Digital Computational Methods
Course development and delivery including lecture and lab for an 87-student course, with a joint project section with another course. **4.4/5.0.**

LEADERSHIP and SERVICE

Boise State University, Boise, ID, USA
2021 – present *College of Engineering*

- Member, Dean Lighty's *Creating Pathways and Forward Progress Task Force*

2020 – present *Mechanical and Biomedical Engineering Department*

- Faculty Search Committee for 2 Tenure-Track faculty members, 2021-2022
- Member, Systems Engineering Curriculum Committee, 2020-2021.
- Member, Graduate Committee
- Member, Biomedical Minor Engineering Committee

University of Arkansas for Medical Sciences, Little Rock, AR, USA.
2017 – 2020 *Orthopaedic Surgery Department*

- Director, Translational Orthopaedic Research
- Orthopaedic Resident Research Committee, Member
- Orthopaedic Resident Interviewer
- Organized seminars/lectures from:
  - Landon Hamilton, Ph.D., 2020
  - Kaitlin Gallagher, Ph.D., 2019
  - Michael Harris, Ph.D., 2019
  - Brecca Gaffney, Ph.D., 2019
  - Paul Rullkoetter, Ph.D., 2018.

2017 – 2020 *College of Medicine*

- UAMS Graduate Student Research Summit Abstract Reviewer
- UAMS Graduate Student Research Summit Poster Competition Judge
- Medical Student Interviewer
- UAMS Women's Faculty Development Caucus
- Center for Health Literacy, Orthopaedic Research Work Group Member

Community Outreach
Boise, ID, USA
2021 She Tech Idaho virtual conference Career Highlight Speaker.

Little Rock, AR, USA

2019 Job shadowing for Central High School students.
2019 Mount St. Mary's Girls' High School Class Lab Visit.
2019 UAMS Community Partnership with Little Rock's Museum of Discovery.
2019 Mount St. Mary's Math Club Invited Speaker.
2019 Harding University Biomedical Engineering tour.
2018 The Buzz 103.7 Sports Radio show guest, *Golf Biomechanics*.
2018 *Little Rock Science Café*, Panel member and radio show guest.
2018, 2019 Museum of Discovery Girls in STEM Summer Camp, Mentor and Field Trip Host.
2018 + University of Kansas Self Graduate Fellowship Mentorship Program, Mentor.

Fort Scott, KS, USA

2019 Invited Speaker to *Area Women Educators* monthly meeting.
2018, 2019 Annual Lecture on Engineering and Biomechanics to Fort Scott High School.

Grant and Award Reviewing Experience

2022 American Society of Biomechanics, Early Career Achievement Award Reviewer.
2021 INBRE Reviewer.
2020 *Early Career Reviewer,* Center for Scientific Review, Clinical Translational Imaging Sciences study section, National Institutes of Health. February, 2020; San Francisco, CA.
2020 *INBRE Reviewer*, Translational Research Institute, UAMS. January, 2020; Little Rock, AR.

Peer-Reviewing Experience

- Mountain West Biomechanics Society 2022 Regional Meeting, abstracts
- Frontiers in Bioengineering
- Orthopaedic Research Society's Harris Award Selection Committee
- Orthopaedic Research Society 2020 Annual Meeting, hip abstracts
- Infant Behavior and Development
- Journal of Biomechanics
- Gait and Posture
- Journal of Orthopaedic Research
- Computer Methods in Biomechanics and Biomedical Engineering
- ASME Journal of Biomechanical Engineering
- Scientific Reports
- Journal of International Medical Research
- Journal of Engineering in Medicine
- Open Biomedical Engineering Journal
- American Society of Biomechanics Annual Meeting abstracts
- Orthopaedic Research Society 2019 Annual Meeting, spine abstracts
- Gait and Clinical Movement Analysis Society 2019 Annual Conference Abstracts

Academic Conference Session Moderator / Judge

2022 "Hip Diagnostics" session co-moderator, *Orthopaedic Research Society Annual Meeting;* Tampa, FL.
2021 "Pediatrics" session co-moderator, *American Society of Biomechanics Annual Meeting;* virtual due to COVID-19.
2021 *Graduate Student Showcase* judge, Boise State University.

2020	"Pregnancy and Infancy" session moderator, *Mid-South American Society of Biomechanics Regional Conference*, Memphis, TN.
2020	"Hip Dysplasia Research Interest Group" session moderator, *Orthopaedic Research Society Annual Meeting,* Phoenix, AZ.
2020	"Spine Interventions and Diagnostics" session moderator, *Orthopaedic Research Society Annual Meeting,* Phoenix, AZ.
2019	"Biomechanics" session moderator, *The 2nd Annual Hip Dysplasia International Symposium*; New York City, NY.
2019	"Lumbar Spine 1" session chair, *International Society of Biomechanics / American Society of Biomechanics Joint Meeting*; Calgary, Canada.
2019	Student podium judge, *South Central American Society of Biomechanics*; Plano, TX.
2018	Student podium judge, *South Central American Society of Biomechanics*,; Dallas, TX.
2018	"Posture," co-moderator, *Mid-South Biomechanics Conference*; Memphis, TN.
2017	"Posture and Balance," co-moderator, *Rocky Mountain American Society of Biomechanics*; Estes Park, CO.

Collegiate Leadership Highlights, University of Kansas, Lawrence, KS, USA

2010 – 2013	Graduate Student Manager, NSF Research Experience for Teachers.
2011	Strategic Planning Steering Committee: Elevating Doctoral Education.
2008 – 2009	Chairperson of the Mechanical Engineering Student Advisory Board.
2008 – 2009	President of Pi Tau Sigma Kansas Psi.
2007 – 2008	President of Engineering Student Council.

MEDIA

2019-2020 Inclined Sleeper Research: International, National, and Regional Media Coverage
Website to all links: https://sites.google.com/view/mannenstudynews/home

1. *U.S. Consumer Product Safety Commission Report* - https://www.cpsc.gov/s3fs-public/SupplementalNoticeofProposedRulemakingforInfantSleepProducts_10_16_2019.pdf?TPVAJZEQcz9x9sKeEGltm4LskkonxUWv
2. *Washington Post* - https://www.washingtonpost.com/business/2019/10/17/study-concludes-design-rock-n-play-other-infant-sleepers-led-deaths/
3. *CBS News* - https://www.cbsnews.com/news/study-finds-fisher-price-rock-n-play-design-led-to-deaths-2019-10-17/
4. *6ABC Philadelphia* - https://6abc.com/family/new-rule-could-end-sale-of-inclined-sleepers/5626834/
5. *KATV* - https://katv.com/news/local/arkansas-doctors-warning-against-inclined-sleepers
6. *KARK 4 News* - https://www.youtube.com/watch?v=yXWr6tx-37g
7. *Consumer Reports* - https://www.consumerreports.org/child-safety/all-infant-inclined-sleep-products-should-be-recalled-consumer-reports-says/
8. *Consumer Affairs* - https://www.consumeraffairs.com/news/feds-propose-ban-on-infant-inclined-sleepers-as-reported-death-toll-rises-101819.html
9. *CBS Boston* - https://boston.cbslocal.com/2019/10/18/cpsc-inclined-baby-sleepers-ban-infant-deaths/
10. *Chicago Sun Times* - https://chicago.suntimes.com/consumer-affairs/2019/10/17/20919701/cpsc-inclined-sleeper-baby-deaths-safety-consumer
11. *Scripps National News* - https://www.youtube.com/watch?reload=9&v=4EYeoq5XANw
12. *10TV WBNS* - https://www.10tv.com/article/study-finds-fisher-price-rock-n-play-design-led-deaths-2019-oct

13. *WKRN Nashville* - https://www.wkrn.com/news/federal-agency-proposes-banning-incline-baby-sleepers/
14. *WPRI* - https://www.wpri.com/recalls-and-warnings/federal-agency-proposes-ban-on-inclining-baby-sleepers/
15. *KXNet* - https://www.kxnet.com/news/national-news/study-finds-fisher-price-rock-n-play-design-led-to-deaths/
16. *UAMS News* - https://news.uams.edu/2019/10/17/research-into-baby-biomechanics-shows-issues-with-infant-inclined-sleepers/
17. *Mother.ly* - https://www.mother.ly/news/co-sleeper-products-safety-consumer-reports-investigates?rebelltitem=1#rebelltitem1
18. *Healthcare Journal Arkansas* - http://www.healthcarejournalar.com/news/research-into-baby-biomechanics-shows-issues-with-infant-inclined-sleepers
19. *Houston Chronicle* - https://www.chron.com/news/article/Study-concludes-design-of-Rock-n-Play-other-14541143.php
20. *AAP Statement* - https://www.aap.org/en-us/about-the-aap/aap-press-room/Pages/AAPStatementCPSCInclinedSleepers.aspx
21. *Romper* - https://www.romper.com/p/ban-on-inclined-sleepers-proposed-by-cpsc-following-reports-of-infant-death-19251691
22. *Insider* - https://www.insider.com/no-inclined-sleepers-are-safe-for-babies-new-report-finds-2019-11
23. *Consumer Reports* - https://www.consumerreports.org/child-safety/new-evidence-shows-more-infant-deaths-tied-to-inclined-sleepers-than-previously-reported/
24. *Consumer Reports* - https://www.consumerreports.org/child-safety/while-they-were-sleeping/
25. *What to Expect* - https://www.whattoexpect.com/news/family/cpsc-inclined-sleeper-recall/
26. *What to Expect* - https://www.whattoexpect.com/news/family/inclined-sleeper-cpsc-warning/
27. *Scary Mommy* - scarymommy.com/retailers-end-sales-inclined-sleepers-infant-deaths/
28. *WebMD* - https://www.webmd.com/parenting/baby/news/20191107/cspc-sleeping-on-an-incline-not-safe-for-baby

HONORS, AWARDS, AND FELLOWSHIPS

2021 **American Society of Biomechanics Early Career Achievement Award**, given annually to one member.

2021 **Kids in Danger's Best Friend Award**, given to one professional annually who made a profound difference in child product safety, Chicago, IL.

2020 **Orthopaedic Research Society's Harris Award for Basic and Clinical Hip Research**, Finalist Dr. Safeer Siddicky for Siddicky SF, Wang J, Tackett SA, Buchele L, Rabenhorst BR, Mannen EM. "Impact of infant gear on hip position and muscle activity," *Journal of Orthopaedic Research*.

2020 Arkansas Business Healthcare Hero: Innovation Hero Nominee, Little Rock, AR.

2019 Phenomenal Woman Awardee, University of Arkansas for Medical Sciences.

2015 – 2017 Postdoctoral Research Fellow, University of Denver.

2010 – 2014 Madison and Lila Self Graduate Fellow, University of Kansas.

2009 – 2010 Institute for Advancing Medical Innovation Fellow, University of Kansas.

2009 – 2010 Woman of Distinction, University of Kansas.

2009 Locke Award for the Outstanding School of Engineering Senior, University of Kansas.

2009 Outstanding Mechanical Engineering Senior, University of Kansas.

2009 Outstanding Woman Student in Leadership, University of Kansas.
2008 Outstanding Mechanical Engineering Leader, University of Kansas.

PROFESSIONAL AFFILIATIONS

2019 - 2020 Gait and Clinical Movement Analysis Society, Member.
2017 - 2020 North American Spine Society, Affiliate Member.
2016 + American Society of Biomechanics, Member.
2014 + Orthopaedic Research Society, Associate Member.
2014 + Society of Self Fellows, Member.
2009 – 2010 Society for Biomaterials, Student Member.
2008 + Pi Tau Sigma, Mechanical Engineering Honors Society, Member.
2007 + Tau Beta Pi, Engineering Honors Society, Member.

INDUSTRY EXPERIENCE

2020 + **Mannen Bio, LLC,** *Owner*, Boise, ID, USA
2017 – 2020 **Mannen Bio, LLC,** *Owner*, Little Rock, AR, USA.
Engineering consulting and expert witness services in biomechanics and infant products.
2011 – 2015 **Engineering Consultant** (unpaid), *Applied Test Systems*, Butler, PA, USA.
2009 **Engineering Intern**, *Oread Medical*, Lenexa, KS, USA.
2008 **Research & Development Intern**, *Stryker Endoscopy*, San Jose, CA, USA.

MENTORSHIP/STUDENT SUPERVISION

Research Scientist

Boise State University

1. Safeer Siddicky, Ph.D., BABI Laboratory, Summer 2020 to Fall 2022.

Post-Doctoral Fellows

University of Arkansas for Medical Science

1. Junsig Wang, Ph.D., Human Motion Laboratory, 2018 to 2020.
2. Safeer Siddicky, Ph.D., Human Motion Laboratory, 2018 to 2020.
3. Anna Cecilia Severin, Ph.D., Human Motion Laboratory, 2018 to 2020.

Orthopaedic International Research Fellows

University of Arkansas for Medical Science

1. Ryota Katsumi, M.D., Translational Orthopaedic Research, Fall 2018 to 2020.

Graduate Students

Boise State University

1. Sarah Goldrod, Masters in Science Student in Mechanical Engineering, Role: **Primary Advisor.** Spring 2022 to current.
2. Abby Brittain, Ph.D. Student in Biomedical Engineering, Role: **Primary Advisor.** Fall 2021 to current.
3. Danielle Siegel, Ph.D. Student in Biomedical Engineering, Role: **Primary Advisor**. Fall 2020 to current.
4. Wyatt Davis, Masters in Science Student in Mechanical Engineering, Role: **Primary Advisor**. Fall 2020 to current.

5. Amy Holcomb, Masters in Science Student in Mechanical Engineering, Role: **Committee Member**. Fall 2020 to Spring 2021. Graduated with M.S. in Spring 2021.

University of Arkansas for Medical Sciences

6. John Sherrill, Doctoral Graduate Program in Interdisciplinary Biomedical Sciences, *Role*: **Primary Advisor**. Fall 2017 to current. Passed Candidacy Exam Spring 2019. Graduated with June 2020. Currently Post-Doctoral Fellow at UAMS.
7. Hannah Simpson, Graduate Program in Interdisciplinary Biomedical Sciences, *Role*: Rotation Advisor, 2019.
8. Pearl Doiphode, Summer Intern, Exercise Science Masters Student, University of Central Arkansas, Conway, AR, *Role*: Summer Intern Advisor, 2019.

Residents

University of Arkansas for Medical Science

1. Robert Achilike, PGY2, Kinematic Knee Alignment of OA Patients, Spring 2019 to present.
2. Sophie Hollenberg, PGY2, Golf Biomechanics in Spinal Fusion Patients, Spring 2019 to present.
3. James Kee, PGY2, Infant Hip Ultrasound Study, Spring 2019 to present.
4. Wes Mayes, PGY4, Knee Fusion Project, Fall 2018 to present.
5. Margaret Wilson, PGY3, Yoga Biomechanics Study, Fall 2017 to Spring 2018.
6. Kaleb Smithson, PGY3, Radiocapitellar Pressure Distribution Study, Spring 2018 to present.

Medical Students

Idaho College of Osteopathic Medicine

1. Olivia Scholes, Y2, Infant Rolling Study, Fall 2020 to current.
2. Abby Prow, Y2, Infant Rolling Study, Fall 2020 to current.

University of Arkansas for Medical Science

3. Jason Eckels, M2, Infant Hip Ultrasounds Study, Summer 2019 to Summer 2020.
4. Samantha Mohler, M1, Infant Hip Modeling Study, Spring 2019 to Summer 2020.
5. Cole Howie, M1, Flexion Instability Biomechanics, Spring 2019 to Summer 2020.
6. Scott Cole, M3, Ulna and Radial uCT Evaluation, Spring 2019 to Summer 2020.
7. Sidhant S. Dalal, M1, Validation of a Spine Testing Machine Study and Infant Hip Ultrasound Study, Fall 2018 to Spring 2019.
8. R. Pearson Gean, M3, Biomechanics of a Shoe-Lift, Spring 2018 to Summer 2019.
9. Akshay Krishnan, M3, Healthy Infant Biomechanics Study, Fall 2017 to Summer 2020.
10. Michael Elkins, M3, Yoga Ankle Biomechanics Study, Fall 2017 to Spring 2018 Summer 2019.
11. Caroline Chen, M3, Validation of a Spine Testing Machine Study, Spring 2018 to Summer 2019.
12. Jacob Smith, M1, Radiocapitellar Pressure Distribution Study, Spring 2018 to current.

Medical Student Honors Research

1. Jason Eckels, M2, Infant Hip Ultrasounds Study, Summer 2019 to Summer 2020.
2. Samantha Mohler, M1, Infant Hip Modeling Study, Spring 2019 to Summer 2020.
3. Howie Cole, M1, Flexion Instability Biomechanics, Spring 2019 to Summer 2020
4. Sidhant S. Dalal, M1, Infant Hip Ultrasound Study, Fall 2018 to Spring 2019.

Undergraduate Research Funding Awardees

Boise State University

1. Sarah Goldrod, Mechanical Engineering, *Boise State University,* HERC Fellowship ($3,000), Spring 2021.
2. Holly Olvera, Mechanical Engineering, *Boise State University,* LSAMP Fellowship ($2,500), Summer 2021.

3. Sarah Goldrod, Mechanical Engineering, *Boise State University,* LSAMP Fellowship ($2,500), Summer 2021.

University of Arkansas for Medical Sciences

4. Lauren Buchele, Biomedical Engineering, *University of Arkansas,* Undergraduate Honors Travel Grant ($1,250), Summer 2018.

University of Denver

5. Alexandra Kahney, Biology, Undergraduate Honors Travel Grant ($1,000), Summer 2017.
6. Alexandra Kahney, Biology, Undergraduate Travel Grant ($544), Spring 2017.
7. Alexandra Kahney, Biology, Partners in Scholarship Grant ($1,500), Spring 2017.
8. Amira Otmane, Biology, Undergraduate Travel Grant ($1,000), Spring 2017.
9. Melissa Jackels, Biology, Undergraduate Travel Grant ($1,000), Spring 2017.
10. Amira Otmane, Biology, Partners in Scholarship Grant ($1,500), Fall 2016.
11. Elizabeth Bachman, Mechanical Engineering, Partners in Scholarship Grant ($1,500), Fall 2016.
12. Melissa Jackels, Biology, Summer Research Grant ($3,500), Summer 2016.
13. Amira Otmane, Biology, P3 Diversity Research Fellowship ($1,500), Summer 2016.
14. Kendra Reilly, Biology, Summer Research Grant ($3,500), Summer 2016.

University of Kansas, Mechanical Engineering

15. Christopher Dill, Undergraduate Research Award ($2,500), Summer 2013.
16. Ana Villanueva, Undergraduate Research Award ($2,500), Summer 2013.
17. Emily Shipman, Undergraduate Research Award ($2,500), Fall 2012 to Spring 2013.
18. Haley McKee, Undergraduate Research Award ($2,500), Fall 2012 to Spring 2013.

Undergraduate Honors Senior Thesis Advisees

University of Arkansas for Medical Sciences

1. Lauren Buchele, Biomedical Engineering, *University of Arkansas,* Biomedical Engineering, Summer 2018 research; graduated with honors 2019.

University of Denver

2. Alexandra Kahney, Biology, Summer 2016 to Summer 2017.
3. Melissa Jackels, Biology, Spring 2016 to Summer 2017.

Undergraduate Senior Design Mentees

1. "Powered Pavlik," Harding University (Searcy, AR) Engineering Research Team (Ray Price, Fabiola Castellanos, Juan Prieto, Cole Brooks, Tymme McCracken), 2018 to 2019.

Undergraduate Research Assistants

Boise State University

1. Pardis Kabeh, Engineering Plus, Summer 2021 to current.
2. Holly Olvera, Research Assistant, Mechanical Engineering, Summer 2021 to current.
3. Sarah Goldrod, Research Assistant, Mechanical Engineering, Fall 2020 to current.

University of Arkansas for Medical Sciences

4. Nicholas Powell, Intern, (Biomedical Engineering, University of Arkansas), Summer 2019.
5. Tanner Holloway, Intern, (Biomedical Engineering, Harding University), Summer 2019.
6. Micah Self, Intern, (Biomedical Engineering, Wichita State University), Summer 2019.
7. Samuel Hockett, Intern, (Biomedical Engineering, Harding University), Summer 2019.
8. Lauren Buchele, Intern, (Biomedical Engineering, University of Arkansas), Summer 2018.
9. Wyatt Davis, Intern (Biomedical Engineering, University of Texas), Summers 2017 and 2018.

10. Sally Barnes, Intern (Biology, University of Arkansas), Summer 2018.
11. William Dean, Intern (Biomedical Engineering, Mississippi State University), Summer 2018.

University of Denver

12. Alexandra Kahney, Biology, Summer 2016 to Summer 2017.
13. Tannah Powell, Mechanical Engineering, Spring 2017.
14. Benjamin Muratov, Mechanical Engineering, Fall 2016 to Summer 2017.
15. Kwabena Asare, Mechanical Engineering, Fall 2016 to Summer 2017.
16. Dylan Merritt, Mechanical Engineering, Fall 2016 to Summer 2017.
17. Daniel Parades, Mechanical Engineering, Fall 2016 to Summer 2017.
18. Cheyenne Bu, Mechanical Engineering, Summer 2016 to Summer 2017.
19. Andriy Novykov, Mechanical Engineering, Fall 2016.
20. Kendra Reilly, Biology, Spring 2016 to Summer 2017.
21. Melissa Jackels, Biology, Spring 2016 to Summer 2017.
22. Thomas Marks, Computer Science, Fall 2015 to Summer 2017.
23. Aidan Griffin, Mechanical Engineering, Summer 2016 to Fall 2016.
24. Madison Kim, Biology, Spring 2016 to Fall 2016.
25. Sarah Walden, Mechanical Engineering, Summer 2016 to Fall 2016.
26. Macy Jones, Biology, Summer 2016 to Spring 2017.
27. Shayla Shell, Physical Therapy, Summer 2016
28. Audrey Adler, Biology, Spring 2016 to Spring 2017.
29. Elizabeth Kirchoff, Human Rights Graduate Studies, Fall 2015 to Summer 2016.
30. Cole Pollina, Biology, Spring 2016 to Spring 2017.
31. Emily Wynne, Biology, Spring 2016 to Summer 2016.

University of Kansas, Mechanical Engineering

32. Patrick Nachtsheim, Spring 2013 to Fall 2013.
33. Alex Schoenberg, Spring 2013 to Fall 2013.
34. Emily Shipman, Summer 2010 to Spring 2013.
35. Haley McKee, Summer 2011 to Spring 2013.
36. Markie McConkey, Fall 2010 to Spring 2011.